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THE
BRITISH JOURNAL OF SURGERY

VOL. XI. OCTOBER, 1923. No. 42.

EPONYMS.

BY SIR D'ARCY POWER, K.B.E., LONDON.

X. POTT'S PUFFY TUMOUR.

THE Observations on the Nature and Consequences of those Injuries to which the Head is liable from external Violence was published in 1760, and immediately placed Pott in the first rank of contemporary surgeons. The essay is original, well written, shows an extensive knowledge of surgical literature, and is full of case-histories which are a perfect joy to read, for they tell of the rough and tumble life in London during the first half of the eighteenth century. When it was published Pott was forty-six years old and had been surgeon to St. Bartholomew's Hospital for eleven years. Four years previously he had been confined to his bed for a considerable period with a broken leg, and this essay is doubtless one of the means he took to relieve the monotony of his convalescence. Indeed, his biographer states that "the appearance of Mr. Pott as an author was an immediate effect of this accident. It was then not an early period of his life: and it is possible, that the busy scene in which he had been engaged might have occupied his mind much longer, and that without some powerful check to the train of his pursuits he might never have discovered in himself those superior powers of scientifical disquisition, that correct taste and masterly command of language, which have placed him in the first rank of medical writers. Engaged from early youth in the constant transaction of business, he probably till this period had indulged but little in the pleasures of speculative investigation, but was never afterwards long unemployed in some literary work".

The alliteration of 'Pott's puffy tumour' seems to have taken a firm hold of the surgical mind, although the condition is of no great importance and is now rarely seen. The passages describing it are contained in the second section of the *Observations* which deals with the effects of contusion on the dura mater and parts within the skull. After discussing whether the cerebral symptoms due to intracranial hæmorrhage can be distinguished from those due to suppuration, he says: "If there be neither fissure nor fracture of the skull, nor extravasation, nor commotion underneath it, and the scalp be

neither considerably bruised, nor wounded, the mischief is seldom discovered, or attended to for some few days. The first attack is, generally, by pain in the part which received the blow. This pain, though beginning in that point, is soon extended all over the head, and is attended with a languor, or dejection of strength and spirits, which are soon followed by a nausea, and inclination to vomit, a vertigo or giddiness, a quick and hard pulse and an incapacity of sleeping, at least quietly. A day or two after this attack, if no means preventative of inflammation are used, the part stricken generally swells, and becomes puffy and tender, but not painful; neither does the tumour rise to any considerable height, or spread to any great extent. If this tumid part of the scalp be now divided, the pericranium will be found of a darkish hue, and either quite detached, or very easily separable from the scull, between which and it, will be found a small quantity of a dark-coloured ichor."

The sign is referred to a little later on in the argument, when he says: "If the symptoms of pressure, such as stupidity, loss of sense, voluntary motion, etc., appear some few days after the head has suffered injury from external mischief, they do most probably imply an effusion of a fluid somewhere; this effusion may be in the substance of the brain, in its ventricles, between its membranes, or on the surface of the dura mater; and which of these is the real situation of such extravasation is a matter of great uncertainty; none of them being attended with any peculiar mark, or sign that can be depended upon, as pointing it out precisely; but the inflammation of the dura mater, and the formation of matter between it and the skull, in consequence of contusion, is generally indicated and preceded by one which I have hardly ever known to fail; I mean a puffy, circumscribed, indolent tumour of the scalp, and a spontaneous separation of the pericranium, from the skull under such tumour. These appearances therefore following a smart blow on the head, and attended with languor, pain, restlessness, watching, quick pulse, head-ache, and slight irregular shiverings, do almost infallibly indicate an inflamed dura mater, and pus, either forming or formed between it and the cranium."

The causes of the smart blow on the head are given in the illustrative cases appended to the essay: "A poor fellow crossing Tower-hill, got, before he was aware of it, into a mob, that was endeavouring to rescue a sailor from a press-gang. The man was knocked down. When the crowd dispersed he was found senseless, and in that state was brought to St. Bartholomew's hospital; where he was immediately let blood, and put to bed. At the end of three days the man found himself so well, as to leave the hospital, and go to work. On the twelfth day from that of the accident, he came to my surgery, and complained of being much out of order. He looked ill, assured me he had lived very soberly from the time of his leaving the hospital. I took him into the house again, bled him, ordered him a glyster immediately, and that he should be kept in bed. On the 15th day after the accident the tumour of the scalp was more apparent, but yet seemed to contain little or no fluid, and was about the breadth of a crown piece. I would have removed that portion of scalp; but while I was intending it, the poor man had a very severe rigor, which disordered him so much, that he begged to be let alone for the

present. The next morning the tumour was more risen, contained palpably a fluid, but was by no means tense; I took away the whole tumid piece, by a circular incision. That whole night and next day he was delirious; his skin burning hot; he had frequent spasms, which shook his whole frame, and that night (the 17th from the injury) he died."

Another case was that of " a young fellow of about twenty years who was thrown from an unruly horse against one of the rails in Smithfield. The blow was great; he lay senseless for above an hour, and in that state was brought into St. Bartholomew's hospital."

" A man in the neighbourhood of St. Giles's had a quarrel with his wife in which he struck her over the head with a mop-stick. The blow was a smart one; but as it neither fetched blood, nor brought her to the ground, it only finished the dispute, and no farther notice was taken of it. The woman followed her business, which was that of crying greens about the streets, and lived, (to use her own words) sometimes drunk, sometimes sober, for a week. On the eighth day from that of the blow, she found herself so ill, that she applied to the hospital for admission; and was taken in as a physician's patient for a fever. The doctor wrote for her; and the day after this, (the tenth day from the accident) the sister of the ward, in cutting off the patient's hair which was full of vermine, discovered a swelling, which she desired me to look at; it was flattish, about the breadth of the palm of a hand; and lay immediately a-cross the sagittal suture. I opened the tumour, and finding the bone bare, cleared away the scalp largely, and circularly. I then applied a trephine on one side of the suture and close to it; and found the dura mater altered in its natural colour, and as it were smeared over with matter." She had an attack of erysipelas, was trephined twice more, and died on the sixteenth day.

" A Lunatic threw himself from a window, two stories high, and in his fall, struck his head first again a sign-iron and then against a slated pent-house. He was taken up senseless and remained stupid above twelve hours, but being in that space of time let blood freely twice, he recovered his senses, but showed no signs of a right understanding. He passed two days and nights in the utmost disorder and disturbance. He was confined in a strait waistcoat and kept two people constantly employed in holding him; at last by repeated phlebotomy, and taking a large quantity of opium, he fell asleep, slept near twelve hours, and then awoke perfectly tranquil and perfectly rational. He would have been permitted by his friends to have gone out a little way into the country; but lest there should be any latent mischief, I advised him to keep quiet a little longer, and to live with great caution; which advice was followed. On the tenth day from that of the accident, he lost his appetite, looked dull and languid, refused food and company; complained that his head ached, and said, that he had not slept. So little time had passed since he had been disordered in his mind that, from his aspect and manner, I suspected a return of his lunacy. I let him blood again, directed that he might be kept low, and desired his brother, who was an apothecary, to give him an opiate at going to bed." In spite of this treatment he got worse, part of his scalp was removed, he was trephined three times, an abscess was evacuated, and he recovered.

"A Watchman whose stand was in Whitechapel, got into a scuffle with some drunken sailors, and received several wounds and blows on his head; from some of which he lost so much blood that he was the next day brought into St. Bartholomew's hospital in a very weak low state. As he had already sustained great loss of blood and was more than sixty years old I made use of no further evacuation, but dressed his head superficially, and directed that he should be kept in bed. At the end of about a week, the general tumefaction of the head was nearly gone, and all the wounds in a healing state; the man transgressed rules of the hospital by staying out all night, and was discharged. On the fifteenth day from that of the accident he came to me again complaining of headach, giddiness, sickness, failure of strength, loss of appetite, and want of sleep. I took him into the house again, removed a circular portion of the scalp including the wound, found bare bone, perforated it in the middle and found a small quantity of matter on the surface of the dura mater. Another perforation was made on the eighteenth day and a third on the twentieth. This procured so large a discharge of pus, that I was very apprehensive that the extent of the mischief was too great for the assistance of art to prove effectual in; however, I was luckily disappointed; for in a very few days more all his bad symptoms gradually left him, and the man got perfectly well."

"A Drayman, drunk, and sleeping, fell from his dray, and his head was so squeezed between the wheel and a post that a considerable portion of the scalp, together with the pericranium was forced from off each parietal bone. He was brought to the hospital senseless; he was largely let blood, the separated scalp was removed and the bone dressed with dry lint. The next day the man was so well and so perfectly master of what sense he had, that I was inclined to believe that a great deal of the last night's appearance was owing principally to liquor. On the thirteenth day he was so well, that having a large family to work for, he desired to be discharged from the hospital, and to be made an out-patient; but I had so often been deceived by the fallacious appearance of such cases that I persuaded him to stay another week. Cerebral symptoms appeared on the sixteenth day and on the seventeenth he was so ill that I fain would have set on a trephine, but the man would not permit me. On the twenty-third day from that of the accident he died, having been paralytic in his leg and arm from the twenty-first."

"On the tenth of February 1765, John Biggs, a lad about thirteen years old was driving a horse round in a grinding mill, the horse not being used to the work, ran round very fast; the boy fell and received such a blow from some part of the frame in which the horse worked, that he lay, deprived of sense, for some time, that is, until somebody came in to enquire, why the mill went so rapid. In a few hours, by the assistance of phlebotomy, he seemed to be very well again. His wound was dressed by the family apothecary for a week, during which time he did not seem to have any other complaint, except now and then having a slight head-ach. The wound not healing kindly, the boy being a country boy, hired only for the purpose of driving the mill-horse, and the people with whom he lived being tired of keeping him unemployed, he was brought to the hospital. On the eighth of March he was seised with a fever, beginning with a kind of cold fit. On the tenth he was

much disordered, complained of acute pain in his head, and his wound, which had been healed, broke out again, the pericranium separating from the bone on the twelfth, he became senseless to all outward objects, was convulsed in all his limbs, and jaw-locked. On this day Mr. Crane trepanned him, in the upper, fore and right side of the frontal bone. On the surface of the dura mater was found a considerable quantity of good matter, on the next morning he died.

There are some further case-histories. One of "a young man playing at cudgels in Moorfields who received a stroke on his forehead." Another of "a Gentleman's coachman who was thrown from his box on the road between London and Richmond and received a wound in his forehead. The next day his master, who was governor of St. Bartholomew's and a timorous man, sent the patient into that house." Another of a man who received a severe blow on his head "in that ever memorable defence made by Capt. Gilchrist, on board (as I think) the Southampton man of war, against a most shameful superiority of French force. He was treated at the hospital in Gosport and three weeks later was sent to St. Bartholomew's Hospital and put under the care of Dr. William Pitcairn." A boy belonging to a horse-dealer in Smithfield was thrown from a horse with great violence against one of the sheep-pens. Two female inhabitants of St. Giles' got drunk together and quarrelled; one of them threw a stool at the other and knocked her down. The edge of the stool cut through the scalp and broke the left parietal bone. The girl was dressed that night by somebody in the neighbourhood and she was brought the next morning to the Hospital. On the eighteenth day a tumour appeared on the other side of the head. A trephine was set on but on the twenty-third day she died. "A boy about eight years old, the son of a Jew merchant in the city received a blow on his head with a stick from his tutor. The stroke made him giddy for a few minutes but as no blood was shed and the pain soon ceased he concealed it till it was discovered by his barber that his head was swollen in that part. Mr. Serjant Amyand and Mr. Shipton were joined with me in the case. We found that the sagittal suture was broken, and that a portion of the fracture was forced into the sinus. After much deliberation and conversation about the hazard of wounding a sinus (which was indeed already wounded by the broken bone) it was agreed to set a trephine on the suture in such a manner that the whole surface should be comprehended within its circle. This was done; and the patient is alive at the time of my writing this." "A girl about fourteen was knocked down by her mother with an iron poker of considerable weight; the latter immediately ran away and the former was brought senseless to the hospital." She died on the seventeenth day. "A girl about fifteen years old, crossing Smithfield on a market-day, was tossed by an ox, and fell with her head on the flat stones within the posts. As her dress was mean, and nobody knew anything of her, she was brought senseless into the hospital. She died on the twentieth day from that of the accident having been terribly shaken by spasms for several hours." "A boy about fourteen years old following a led horse, was desired by the servant, in whose hand the horse was, to strike him; the boy did so, and received a blow from one of the horse's heels, which brought him to the ground senseless. On the twenty-second day he became delirious and

convulsed and on the twenty-third died." "A woman came to my house complaining that her husband had kicked her down stairs and had broke her skull. I took her into the hospital, where she was taken all possible care of, but she became first paralytic, and then comatose and so died."

It is somewhat remarkable that Pott was able to obtain a post-mortem examination of the heads in each of the fatal cases; whilst the time that he must have devoted to the preparation of the essay is shown by the fact that he had read, and quotes, Hippocrates, Celsus, Archigenes, Galen, Oribasius, Paulus Ægineta, Rhazes, Theodoric, Brunus, Lanfrank, Gui de Chauliac, Petrus Argelatus, Berengarius of Carpi, Fallopius, Paww, Fabricius Hildanus, Andreas Croce, Peter of Marchetti, Ambroise Paré, Muys and Wiseman, Le Dran and Morgagni. It is clear that Pott read Latin and French with tolerable ease, for he quotes the originals. Greek authors he always quotes in their Latin dress, so he was probably not equally versed in Greek.

PRIMARY CARCINOMA OF THE LUNG.

A DISCUSSION OF ITS INCIDENCE AND DIAGNOSIS.

By KENNETH PLAYFAIR and CECIL P. G. WAKELEY, London.

INTRODUCTION.

Since the original paper by Bayle over a century ago in which he described a case of primary carcinoma of the lung, many further cases have been recorded. Adler published a treatise in 1912 on *Primary Malignant Growths of the Lungs and Bronchi* in which he records 374 cases of primary carcinoma of the lungs and bronchi collected from literature up to that date. Following Adler's admirable monograph, many further contributions have been made to literature on this subject. It is of significance that during the decade ending in 1922 the three years 1920–22 yield a greater number of recorded cases than do the previous seven years. While the last three years occur immediately after the late war—during which perhaps medical research was directed to the immediate requirements for the benefit of the armies both in the field and in training—yet they are also the three years following on the great pandemic of influenza, which was notable for its ravages on the respiratory system. The etiology of carcinoma of the lung remains as obscure as does that of carcinoma elsewhere; but the apparently increased frequency of the disease arising in this situation since the influenza pandemic of 1918–19 is regarded as significant by most recent writers. Several recent American writers, Moise in 1921 and Barron in 1922 among others, lay particular emphasis on this fact.

The symptomatology and diagnosis have been discussed at length by many. While this rare disease may in its classical form present no great difficulty in diagnosis, yet from the similarity of its symptoms and signs to those found in other more common pulmonary diseases it still offers many difficulties. Records of cases reported in the past decade yield abundant evidence that often either no diagnosis, or an incorrect one, has been made prior to autopsy.

A correct prognosis is impossible while there exists any confusion with tuberculosis. Treatment, in any case of doubtful value in this disease, differs entirely from that in pulmonary tuberculosis. That primary carcinomata of the lung are undoubtedly very rare is evidenced by the few cases recorded in comparison with the common occurrence of carcinomata elsewhere in the body. Yet doubtless many cases undiagnosed in life pass unrecorded from the lack of autopsy. Many cases of pulmonary tuberculosis fail to come to autopsy, and not infrequently cases of pulmonary carcinomata are complicated by this disease. In such circumstances a diagnosis of phthisis

is probably made, being comparatively obvious, as well as being adequate both for purposes of registration and for the satisfaction of the patient's relations.

From the fact that we have been able to find only three cases reported in this country since 1918, while in America more than thirty were recorded by McMahon, Carman, Barron, and others, it might be inferred that this disease was of less common occurrence in this country than in the United States. Yet we are inclined to think that the number of cases in this country would be increased were infirmary statistics investigated. The more chronic cases would be likely to find their way to these institutions, under the economic stress of hospital accommodation here. Again, the lack of routine autopsy in this country may help to account for the apparent difference in frequency in the two countries.

In a thorough search of the clinical and pathological records of King's College Hospital from 1901 to the present date, we were only able to find four clearly established cases in 3183 post-mortem examinations, and a further two in which the clinical diagnosis could not be subsequently confirmed by autopsy; the latter we do not record. This represents only 0·1 per cent of primary carcinomata of the lung at autopsy in the experience of a London teaching hospital extending over 22 years. We were able to investigate every possible case carefully, and have conducted further microscopical examinations in all the doubtful ones. The four reported in this paper are only the cases in which there is no element of doubt in the diagnosis.

ETIOLOGY.

Etiological factors of primary importance, such as tuberculosis and pneumonoconiosis, do not appear to have been present in our four cases. Chronic bronchitis had been present in *Case* 3. It was also present in *Case* 1, associated with asthma of eight years' standing. In *Case* 2, bronchial trouble arose from influenza nine months before the patient came under observation. *Cases* 1 and 3 both denied having ever had influenza in recent years, while *Case* 4 had had influenza three times severely during three successive years about 25 years previously, but apparently there were no subsequent bronchial symptoms. Several American writers lay emphasis on influenza as an etiological factor of immediate importance. Is it not more probable that chronic inflammatory changes in the bronchial mucous membrane provide the antecedent factor, influenza being merely one of many conditions which can result in chronic bronchitis?

It would be of interest to know whether any cases of chronic bronchitis arising after 'gassing' ever develop primary pulmonary neoplasms. We have been unable to discover any record of such an event.

PATHOLOGY.

Ewing states that there are three types of pulmonary carcinomata histologically distinguishable, according as to whether they arise in (*a*) bronchial epithelium, (*b*) bronchial mucous glands, or (*c*) alveolar epithelium. However, there may remain considerable difficulty in the identification of some

cases, this difficulty being directly proportional to the duration and extent of the growth.

In the four cases here reported there is trouble in classification in only one—namely, *Case* 3. They are all columnar-cell carcinomata, but in *Case* 1 (*Fig.* 141) cilia may be observed, and we have therefore considered that it has arisen from the bronchial epithelium. *Case* 2 (*Fig.* 145) and *Case* 4 present histological features very similar to one another.

DIAGNOSIS.

A diagnosis of primary carcinoma of the lung cannot be made without suspecting it. In such a disorder—which from the number of fully recorded cases may no longer be regarded as very rare, yet in comparison with the extremely frequent occurrence of pulmonary tuberculosis may justly be regarded as being comparatively so—the main difficulty lies in the failure to suspect the presence of malignant disease in this situation. Only brief descriptions are as yet to be found in the leading text-books, and—while noted by the reader—are rapidly forgotten. Cramer and Saloz published two papers on the subject. In the first they report 29 cases collected in Geneva during twenty years, in which 80 per cent of cases were not correctly diagnosed before autopsy. Later, in their second paper, they report a further series of 8 cases, with only 25 per cent failure in clinical diagnosis. It would appear that this remarkable improvement in accuracy of diagnosis is due to the fact that primary carcinoma of the lung was, by them, well recognized as a consideration in the differential diagnosis.

Some difficulty in breathing is probably the earliest symptom to arise, and this may be accompanied by a cough, frequently of an unproductive nature. Later, when the growth has involved the pleura, pain, either dull and aching or sharp and stabbing in character, is extremely constant.

Much has been written on the sputum. The 'characteristic' black-currant jelly or prune-juice sputum is of rare occurrence, and even then is only found in the later stages; but hæmorrhage may not infrequently be present. The absence of tubercle bacilli on repeated examination is suggestive, and calls for a careful revision of the diagnosis. Degenerate carcinoma cells with many fatty granules are very conclusive when present. It should not be forgotten, however, that the characters of the sputum will depend on the actual pulmonary condition present. Bronchiectatic, tuberculous, or pneumonic sputa quite typical in character may not infrequently be found, and from that an erroneous diagnosis is made.

The signs present in the earlier stages are usually negative, but later there is impaired mobility of the affected chest, flattening, dullness, diminution of vocal vibrations and air entry—all characteristic of collapse of the lung consequent on the bronchial obstruction, and not of the tumour mass itself. Both ulceration of the tumour with cavity formation, and bronchiectasis may occur, with typical signs, leading to confusion in the diagnosis.

X rays are by some claimed to be absolutely diagnostic. This may be so in a few cases, but from the very nature of the local effects of the tumour the appearances must be not only extremely variable, but not distinctive.

The X-ray appearance of the lung depends on the variations in density of the lung substance. Extensive fibrosis both of lung and pleura, and the occurrence of adherent pleura or pleural effusion, must mask the picture. This may be seen in the skiagram taken in *Case* 1 (*Fig.* 139), in which with the onset of symptoms a well-marked pleural effusion masked all underlying phenomena, and the translucent area at the apex corresponded with the sole remaining portion of lung which was found on clinical examination to be functioning. An almost identical appearance was found in the skiagrams taken in *Case* 4. We would emphasize the fact that while, together with symptoms and clinical signs, X rays prove an extremely useful adjunct to diagnosis, too much reliance must not be placed on skiagrams, to the exclusion of a careful clinical examination.

Bronchoscopy has been performed; it can only be of value when the tumour originates in one of the main bronchi. Lung puncture, at all times an extremely dangerous measure, has been advocated; but the dangers of hæmorrhage and infection of the pleural cavity outweigh the possible value of obtaining a little carcinomatous débris in the material withdrawn.

Since an early diagnosis is imperative prior to any radical treatment being undertaken, the important early symptomatology in primary pulmonary carcinoma is here recapitulated. Some difficulty in breathing, often paroxysmal in type and frequently described as 'asthma', arising in later life, must be regarded with grave suspicion. Cough may be very early, and is frequently troublesome, irritating, and unproductive. The latter we regard as very significant when no local pharyngeal cause is present. Expectoration may be present, but in the earliest stages is rare. The absence of tubercle bacilli on repeated examination is suggestive, while degenerate carcinoma cells, when found, render the diagnosis certain. Hæmoptysis in its various types is unusual till the disease is well advanced, and is then only rarely distinctive. Pain, a very constant symptom, would appear to indicate pleural involvement, and cannot be included in the early symptomatology. The physical signs, which we would emphasize, are dependent on the resultant failure in the inflation of the lung from bronchial obstruction; they are slight flattening, with impaired mobility on respiration, of one side of the chest, with deficient air-entry and impaired note on percussion, and are usually unaccompanied by any evidence of localized consolidation.

TREATMENT.

Surgical.—Very few cases of primary carcinoma of the lung can be treated surgically. Seydell in 1910 stated that he was not at all certain that pulmonary carcinoma could be operated upon with a good result. This is comprehensible, because 90 per cent of primary carcinomata start near the root of the lung and metastasize early. However, Lenhartz was successful in one case out of five. The case was a diffusely infiltrating carcinoma, and almost the whole lung was excised bit by bit. The wound was left open, and systematic X-ray treatment was given until the wound had finally healed. The patient died two and a half years after the operation. Morriston Davies, in his excellent book, *The Surgery of the Lung and Pleura*, reports a successful case of resection of a lobe of the lung for primary carcinoma.

Before the war many devices and many elaborate types of apparatus were brought forward by different surgeons for reducing the pressure outside the thorax of the patient so that the lung might be kept distended during the operation. Fell, O'Dwyer, Matas, Sauerbruch, and Willy Meyer have all invented different kinds of cabinets, but these are clumsy, take up a large amount of room, and are expensive to run. Intratracheal ether insufflation has quite superseded every other method or apparatus which compensates pneumothorax.

It is advisable to give the patient a hypodermic injection of morphia (gr. $\frac{1}{6}$) and atropine (gr. $\frac{1}{100}$) half an hour before the operation.

The fifth rib is excised subperiosteally throughout nearly its whole extent; some surgeons, including Morriston Davies, have not found it necessary to resect a rib, but make an incision through the fifth intercostal space and rely on very strong mechanical retractors to ensure sufficient exposure of the lung. Adhesions between the parietal and visceral layers of the pleura are now divided, and the vagus nerve is injected with novocain in order to abolish post-operative shock. Davies found, as a result of experimental investigation on animals, that the intrathoracic anæsthetization of the vagus completely abolishes the shock of manipulations on the lung.

The affected lobe of the lung is now exposed, and its vessels are defined by blunt dissection and divided between double ligatures. The lung tissue at the base of the lobe is carefully incised, and all bleeding points are immediately ligatured. Especial care is required in dealing with the bronchus, which should be the last structure to be severed. A purse-string suture is passed if possible round the outer coats of this structure, and the bronchus is crushed by a powerful clamp. The actual cautery is finally used to sever the crushed portion of the bronchus. The proximal end of the crushed bronchus is invaginated and the purse-string suture tied. If possible any raw lung tissue is drawn over the stump of the bronchus. A small drainage tube is inserted for forty-eight hours. If, as frequently happens, an effusion takes place, it should be aspirated, with oxygen replacement.

Radiological.—In the almost inevitably fatal course of the disease under the usual methods at our disposal, it would seem that radiation therapy would offer the best chance of arresting a growth of the lung or possibly reducing it to operative proportions. In view of the extremely rare condition, statistics of such methods of treatment are necessarily difficult to obtain. If deep therapy treatment is applied, it is essential that the thoracic region should be mapped out into a series of areas to which the radiations are to be directed. Indications for the necessity of specially pushing treatment in one or more particular areas will be afforded by examinations of skiagrams taken from time to time. In 1922 Rolland, of Paris, treated a case of carcinoma of the hilum of the lung by deep radiation. This treatment caused the primary lung condition to improve considerably, but the man died from a metastasis in the cerebellum.

PROGNOSIS AND COMPLICATIONS.

By the time the clinical and other evidence justifies a diagnosis of primary pulmonary neoplasm, the disease is far advanced and but a few months of life remain. The duration, however, may be very variable—that is to say,

the duration from the first onset of symptoms to the inevitable termination of life. In our series, *Case* 1 strongly suggests an eight-years' history—that is, with the onset of 'asthma' as the first symptom. On the other hand, *Case* 2 presented no symptoms prior to nine months before death, while in *Cases* 3 and 4 there is only three months' history from first to last.

Complications both varied and numerous may arise to add to the discomfort of the patient and to difficulties in diagnosis. Septicæmia, hæmorrhage, pulmonary tuberculosis, bronchiectasis, pneumonia, abscess of the lung, pleurisy, pleural effusion, and empyema are the more common local complications; while the local spread of the growth into the mediastinum, or the invasion of glands in that area, may give rise to many different effects of pressure on any or several of the vessels, nerves, etc., traversing this area.

Metastases from carcinoma of the lungs have been found in all structures of the body, and nothing distinctive appears to be associated with the different histological types.

CONCLUSIONS.

1. Primary carcinoma of the lung, while still correctly regarded as a rare condition, is probably of more frequent occurrence than is usually admitted. Cases reported from America during the past five years are very much more numerous than in this country. This may be a true indication of its relative incidence in the two countries, but it is to be doubted if it is so. Absence of routine autopsy here, and perhaps a reluctance to record such cases, may account for the apparent difference.

2. The etiology is little understood; but the fact that chronic inflammatory affections precede this type of carcinoma may be a factor of importance, as is frequently the case in carcinoma elsewhere. Chronic bronchitis originating from respiratory lesions of influenza may be one of the most important precursors of pulmonary carcinoma.

The pathology is still obscure. Although many cases are readily classified histologically, many others, especially advanced cases, must remain unidentified as regards their exact origin.

3. We would emphasize the need of a constant consideration of primary pulmonary neoplasm in all cases presenting any chronic lung symptoms, such as shortness of breath, cough, hæmoptysis, and thoracic pain. It is upon an early and correct diagnosis that the future of surgery and radiotherapy in treatment must depend.

Diagnosis must primarily depend on a detailed and correct correlation of the history and clinical observations, while radiography, a useful adjunct at times, is too often unreliable. Degenerate carcinoma cells when present in the sputum are diagnostic, but this is a rare occurrence, and may be overlooked during the routine examination for tubercle bacilli.

4. Surgery, with intratracheal anæsthesia, and possibly the simultaneous administration of radiotherapy, offer the only means of eradication of this disease; but progress must be slow until the early symptomatology is more generally recognized.

PARTICULARS OF CASES.

Case 1.—T. H., male, age 47, was admitted on Sept. 20, 1921, complaining of asthma and bronchitis. He had had rheumatic fever fifteen years previously, from which time he dated his chest symptoms of frequent cold and persistent cough. Eight years ago he started attacks of asthma ; four years later he attended a chest hospital for this complaint, with improvement of his symptoms ; but with cessation of treatment his attacks of asthma recurred and had become worse. While generally dyspnœic, he had severe attacks of dyspnœa, described by him as 'asthma', which followed any exertion either during the day or at night. They lasted from ten to fifteen minutes, leaving him very exhausted, and were accompanied by a sharp pain in the left chest and shoulder. There was no history of tuberculosis or venereal disease.

On examination, the temperature ranged between 97° and 101°, and was remittent in type. Respirations were 20 to 24, and pulse about 92. The right side of the chest moved well, but the left side was flat, and did not appear to move on inspiration. Fremitus was absent, and there was dullness on percussion over the whole of the left lung except at the apex in front above the clavicle, where there was a small area of resonance. On auscultation of the left lung no breath-sounds were audible except over the small area of resonance at the apex, where they were distant and feeble, but vesicular in type. No adventitious sounds were present. The physical signs of the right lung were hyper-resonance all over ; well-marked vocal fremitus and the prolongation of audible expiration, together with numerous and varying rhonchi, suggested a diagnosis of emphysema with chronic bronchitis of this lung. There was a slight scoliosis of the dorsal vertebræ, with its convexity towards the right side. The cardiac apex was felt in the 5th space in the nipple line, but could not be defined by percussion. The right border was half an inch to the right of the sternum. There was therefore no cardiac displacement. The heart-sounds were normal. The alimentary and nervous systems presented nothing abnormal. The urine was normal. The sputum, scanty in amount, was frequently examined for tubercle bacilli without any result.

The chest was explored on Oct. 2, 1921, in the area of the 8th interspace in the posterior axillary line, but nothing was obtained. The signs in the chest remained the same, and X-ray examination demonstrated pleural adhesions over the left dome of the diaphragm, with the presence of a pleural effusion. On Oct. 10 paracentesis thoracis was again performed in the left 3rd interspace in the mid-axillary line and greyish thick pus was found. Resection was immediately performed. On opening the pleural cavity, about 15 oz. of thick pus were evacuated, which was followed by a copious hæmorrhage necessitating tight packing. Forty-eight hours later the packing was removed, and replaced by a large drainage tube, the wound being partially sewn up. The patient then rapidly improved. The temperature settled down, and the wound had completely healed by Nov. 24, i.e., six weeks after operation.

The films of pus showed degenerated polymorphonuclear leucocytes and a few degenerate cocci. Cultures grew pneumococci after forty-eight hours. The signs in the lungs remained about the same. The left lung was quite dull on percussion, vocal fremitus was absent, and breath-sounds were just audible over the apex. No adventitious sounds were present in either lung. There were no symptoms at rest, and in this condition he left hospital for a convalescent home. A tentative diagnosis of pulmonary malignant disease was made.

He was re-admitted on Feb. 17, 1922, two and a half months later, as the empyema wound had broken down and was discharging pus. He had been well up to the beginning of February, when he developed a 'cold', followed by an irritating cough. The lung signs were the same as on his former discharge from hospital. The temperature was 99°. A tube was inserted into the sinus and a quantity of pus liberated. He was X-rayed on Feb. 25, the report being : " Complete opacity of left lung except at the apex " (*Fig.* 139). On Feb. 28 a considerable quantity of dark-red viscid fluid was discharged, accompanied by a rise in temperature to 101°. The pus on examination was found to consist of blood-clot only, and no evidence of neoplasm

was detected. At this time he complained of pain and tenderness on removal of the tube. An X-ray examination was made on March 6, the sinus being injected with Beck's paste. Report: "Beck's paste seen in a sinus extending from the level of the diaphragm to root of lung." The temperature rapidly subsided, the cavity became obliterated, and finally the wound had healed before discharge on March 16.

On June 20 he was again re-admitted, complaining of pain in the back, localized to the neighbourhood of the 6th dorsal vertebra. There was dyspnœa on exertion,

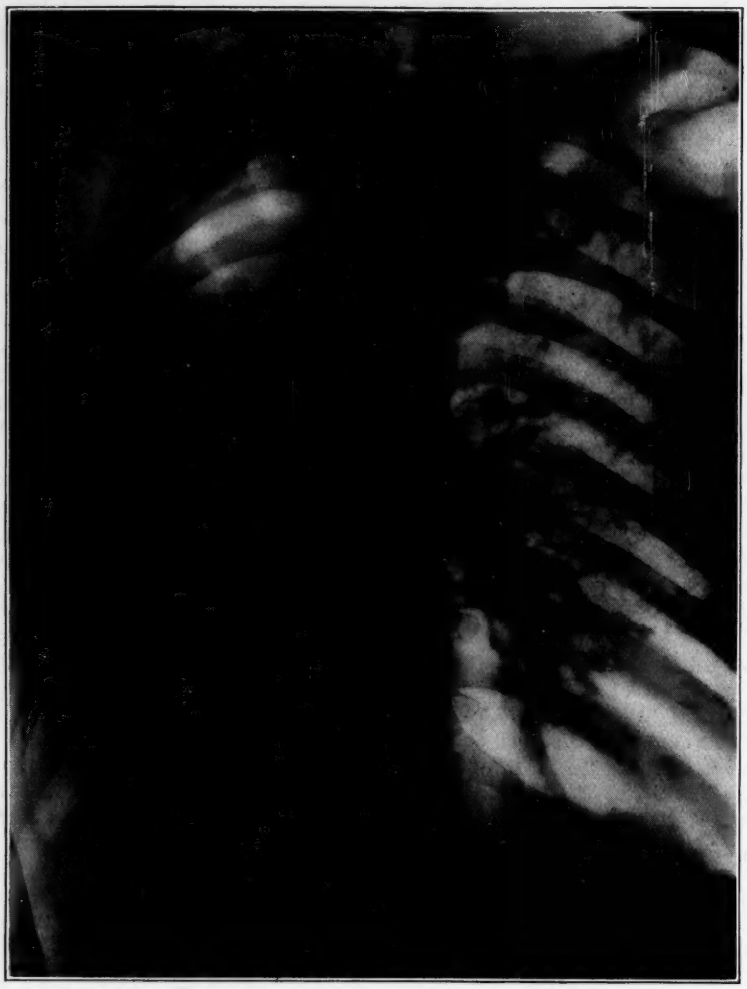

FIG. 139.—*Case* 1. Skiagram, taken on Feb. 25, 1922, showing complete opacity of the left lung except for an oval area at the apex, this corresponding to the small area of functioning lung which gradually became obliterated before death. Slight irregularity of the sides of the 2nd to 5th dorsal vertebræ can be seen, due to direct extension of the lung growth. The right lung shows some hilus fibrosis, with diaphragmatic adhesions. (*Skiagram reversed.*)

and aggravation of pain by any movement. These fresh symptoms, arising shortly after leaving hospital, had been gradually increasing during the past three months. On examination, the heart was normal and apparently not displaced, but the apex was fixed. The lung signs were the same as on the last examination—i.e., marked flattening; absence of expansion, vocal fremitus, and resonance; and complete dullness on percussion over the left lung. The right lung moved well, but was

hyper-resonant on percussion ; vocal fremitus and resonance were good, and a few rhonchi could be heard, mainly in the upper lobe. X-ray examination at this time showed irregularity of outline of the bodies of the 2nd, 3rd, 4th, and 5th dorsal vertebræ, but no definite destruction of bone ; there was also some curvature of the spine. The right lung was clear, except for some increase of density at the hilus. The left lung was quite opaque.

On July 17, the left chest, one inch smaller than the right, was flat, dull all over,

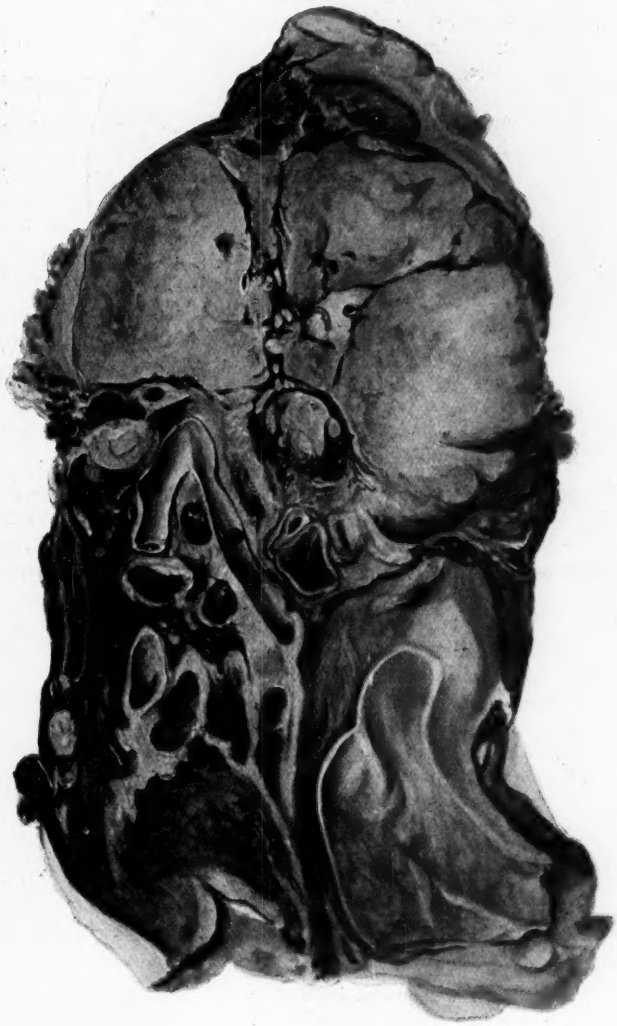

FIG. 140.—*Case* 1. Left lung. The growth is clearly seen involving the whole of the upper lobe with the exception of a small area of complete collapse at the apex. Growth may be seen extending down into the base of the lower lobe external to and compressing the bronchi, which are filled with a very thick brownish secretion, the consistence of firm jelly. In the lower right corner is seen the densely adherent pericardium, while over the apex the pleura, more than a quarter of an inch in thickness, remains to indicate the denseness of the adherent pleura.

and vocal fremitus was absent except for a small area above the 3rd rib, where it was just perceptible. Vocal resonance and breath-sounds were inaudible except over this same area. Massage and breathing exercises were given.

On Aug. 4 the patient complained of slight increasing weakness of the legs. There was definite bilateral spasticity, with increase of tendon reflexes, an extensor plantar response, and absent abdominals. Sensation was much impaired up to the level of the nipples ; a diagnosis of compression paraplegia was made, the lesion being in the neighbourhood of the 5th dorsal vertebra. The blood and cerebrospinal

fluid gave negative Wassermann reactions. Lumbar puncture yielded 20 c.c. of fluid: clear, but faintly yellow in colour, and under slight pressure, containing 2 cells per cubic centimetre. Total protein 0·45 per cent, in very large excess. Globulin reaction strongly positive. Carbohydrate and chlorides normal. Hæmoglobin nil.

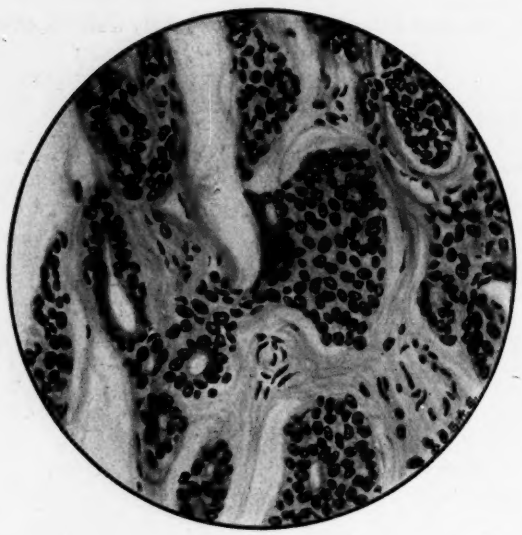

FIG. 141.—*Case* 1. Section of growth in left lung, showing a columnar-celled carcinoma in which most of the carcinoma cells are arranged in masses, in some cases solid, and in others surrounding one or more central spaces containing mucoid material. Where the formation of tubules is well marked and these tubules are lined by epithelium only 2 or 3 cells thick, the cells can be seen to be definitely columnar in type, and in some cases ciliated. The stroma is composed of dense fibrous tissue with a few blood-cells.

Biuret reaction negative. No spontaneous coagulation, and no coagulation on addition of a drop of fresh blood—i.e., Froin's syndrome—except for clotting.

On Aug. 10 a more detailed examination of the nervous signs revealed a complete paralysis of both lower limbs, with painful spasticity of both legs. Pin-prick

FIG. 142.—*Case* 1. The section, taken from the posterior internal margin of the left lung, shows extensive fibrosis with the later stages of complete pulmonary collapse. All cellular structure has completely disappeared, and only elastic fibres remain to identify the tissue. In a thorough search of the rest of the lung which had not been invaded by growth, no areas of a lesser degree of collapse were seen, indicating the extreme degree of universal collapse and fibrosis of the diseased lung.

sensation was absent below the level of the 5th rib on both sides. Sensations of cold and heat, however, were present. There was some incontinence of urine. The condition progressed, and in view of the severity of the pain laminectomy was done to relieve pressure. On removal of the posterior portions of the bony arch from the

2nd to 6th dorsal vertebræ, fairly extensive growth was seen to surround the cord. The dura was divided vertically at the level of the 4th dorsal vertebra for about 1½ in., and two small hard masses were found on the arachnoid, which were removed for microscopical examination.

REPORT.—*Mass from beneath dura mater.* Section shows a fibrous-tissue stroma. In places there are quite young fibroblasts, in others old fully-formed bundles of fibrous tissue. There is in the smaller pieces of tissue submitted what appears to be laminated blood-clot. Throughout the stroma there are scattered mononuclear cells, endothelial in type. The specimen teased out and examined wet showed a similar arrangement, but the endothelial cells were more numerous.

The membranes were distended owing to the pressure of the cerebrospinal fluid, which was partially drained by incision at the 6th dorsal vertebra. No evident abnormal condition of the fluid was noted. The wound was then sewn up, and healed rapidly. The signs of pressure on the cord were not apparently relieved.

FIG. 143.—*Case* 1. This shows part of the bodies of the 2nd, 3rd, and 4th thoracic vertebræ invaded by direct extension from the adjacent primary focus in the lung. The whole of the body of the fourth vertebra is invaded by growth, which extends upwards under the anterior common ligament on the left side.

FIG. 144.—*Case* 1. A transverse section of the cord at the level of the 5th dorsal vertebra, showing general thickening of the dura, with—anteriorly and to the left—a portion of growth which has extended from the lung through the bodies of the vertebræ (4th and 5th dorsal), into the bony canal, and is exerting pressure on the cord at this level. Nowhere have carcinoma cells penetrated the dura.

By Nov. 1 a bed-sore had been developed over the sacrum. Emaciation was now rapidly progressive, with severe pain in the left chest, which had become dull and non-resonant even at the apex. Numerous râles were heard in the right lung. The patient was now under morphia, and presented the typical appearance of advanced cachexia.

On Nov. 14 he developed a large fluctuating mass over the middle of the manubrium sterni, which progressed to the extent of necrosis of the overlying skin before death took place, on Nov. 18, from toxæmia and exhaustion.

AUTOPSY.—The body was wasted. A large ulcerating swelling over the manubrium sterni was present and had resulted from an osteomyelitis of that bone, spontaneous fracture having occurred. The abscess cavity was entirely anterior to

the pericardium, which was greatly thickened. There was also a large and deep sloughing bed-sore over the sacrum, from which the infection in the manubrium had probably arisen.

The heart was not abnormal. The right pleura was normal, save for some recent adhesions along the mesial border anteriorly. The left pleura was enormously thickened and adherent all over, with dense fibrous tissue. The right lung showed a slight degree of fibrosis, with a recent generalized bronchitis. The left lung showed an extreme degree of fibrosis, with complete collapse of the lower lobe (*Figs.* 140, 141, 142). The bronchi were greatly thickened, and at the hilus of the lung the main bronchi were infiltrated with growth and full of a thick brownish jelly-like material. The upper lobe was replaced by a firm, tough growth, apparently arising primarily in that situation, and extending mesially into the bodies of the adjacent vertebræ (*Figs.* 143, 144).

The liver was enlarged, congested, and fatty; the spleen was pale and soft; the kidneys and suprarenals and other viscera contained no secondary deposits.

Case 2.—E. T., female, age 60, was admitted on Jan. 27, 1921, complaining of 'shortness of breath'; she gave a history of influenza nine months previously, and from that date had complained of shortness of breath, which had been getting gradually worse. Later there was pain in the upper part of the left chest, some cough and expectoration, the last-named thick, yellow, and with occasional streaks of blood. There had been a steady loss of weight. She had had no heart or chest trouble previously, and no symptoms of dyspepsia. A maternal relative had had asthma and chronic bronchitis.

FIG. 145.—*Case* 2. Section of left lung. The tumour is a columnar-celled carcinoma in which the columnar cells are lying in spaces of various sizes. The lining cells are only one layer thick, and definitely columnar in type, but have no cilia. There is a dense fibrous supporting stroma, containing blood-vessels.

On examination, the left hemithorax was immobile on respiration, and the veins were somewhat prominent over the upper thorax. There was absolute dullness over the upper lobe in front and at the back. Tubular breathing, crepitations, and pectoriloquy were audible over a small area in the 3rd left intercostal space in front. Air-entry was diminished over the rest of the left lung. The heart was regular, normal, and not displaced. Nothing abnormal was found in the liver, spleen, or alimentary tract. The urine was normal.

On admission, the temperature was 96°, respiration 32, pulse 100. While in hospital she slept badly, and became very dyspnœic on the least effort. On Feb. 9 there was a slight rise of temperature to 99·6°, with respirations 40 to 44, and pulse of 100 to 110. The whole of the left lung was dull on percussion, and there was almost a complete absence of air-entry into the lower lobe. Heart-sounds were remarkably loud, and audible over the whole of the left chest. The right lung presented the signs of early passive congestion. Two days later she was very weak, the signs were the same, and she was very cyanosed. She finally collapsed and died the same day, namely, fifteen days after walking into hospital. The Wassermann was negative, and the diagnosis of mediastinal neoplasm was made from the signs and symptoms. The larynx was normal.

AUTOPSY.—The body was emaciated. The left pleura showed dense adhesions all over, except at the apex, where there was a small empyema. The right pleura contained a considerable quantity of fluid. There was growth under the sternum extending along the 2nd and 3rd ribs on the left side. The left lung was completely solid with growth; the right lung was partially infiltrated with growth. The peritoneum was studded with nodules of new growth; there was no free fluid.

Microscopical Report.—Columnar-celled carcinoma of bronchus (*Fig.* 145).

Case 3.—J. A. F., male, age 53, was admitted on March 18, 1920, complaining of acute pain in the left side of the trunk and extending down into the left leg. He gave the following history. Rapid onset of acute pain in the left side and epigastrium, with vomiting. He also had shortness of breath and a slight cough, but no expectoration. He went to bed after four weeks, but did not improve. The neuralgic character of the pain was very distressing. After remaining a month in bed without any improvement he was admitted to hospital. He had suffered from chronic bronchitis for many years, and thought he had developed 'heart trouble' during the war. Moderate smoker. His father died of asthma with chronic bronchitis. No other family history of pulmonary disease.

On examination, there was shortness of breath and thirst, but no marked emaciation. Pulse 92, respiration 20, temperature 99·5°. The heart was enlarged to the left, the apex being in the 5th space half an inch outside the nipple line, and there was marked pulsation in the 3rd, 4th, and 5th left intercostal spaces. In the precordial areas the cardiac sounds were rather tic-tac, but no bruits were present. There was a flat note over the whole of the left lung in front, with a diminution in vocal fremitus. Vocal resonance was increased, and breath-sounds were bronchial in type. A few rhonchi were audible in the upper lobe. At the back there was absence of vocal fremitus and greatly diminished air-entry, but there were no adventitious sounds. The right lung was apparently normal, and there was no sputum. The alimentary tract was apparently normal. Although there were no urinary symptoms, the urine contained blood and pus.

On March 22 there was a marked leucocytosis with a relative increase of the polymorphonuclear cells. The left chest was now quite dull, and paracentesis thoracis was performed, but no pus or fluid was obtained. The patient developed large purpuric patches on the hands, which cleared up in a few days. He gradually sank; dyspnœa became marked, with drowsiness and cyanosis; the pain improved and latterly disappeared. The left lung became stony dull, and there was complete absence of breath-sounds. The temperature throughout presented morning and evening remissions of 3 to 4 degrees. Respiration 28 to 36, and pulse 120 to 130. The Wassermann was negative.

AUTOPSY.—The body was well nourished, and a nodule of growth the size of a tangerine orange was seen on the outer side of the 7th rib on the right side. Blood-stained fluid was found in both pleural cavities.

The left lung showed a dense mass of growth, which appeared to have originated in the left bronchus. This bronchus was surrounded and filled with growth, and was entirely occluded. The mass extended into the left lung and pleural cavity, behind the œsophagus and between it and the trachea, and round the base of the left lung, binding it to the mediastinum, diaphragm, chest wall, and pericardium, and extending behind the diaphragm into the abdomen. The portion of the upper lobe not affected with growth showed well-marked septic pneumonia. The right lung contained a few scattered nodules of growth.

Secondary deposits were found in both suprarenals, the right kidney, and the heart.

Microscopical Report.—Columnar-celled carcinoma.

Case 4.—J. H., female, age 71, was admitted on Jan. 22, 1923, complaining of pain in the left side of the chest, with a feeling of tightness round the upper thorax, following a 'cold' four weeks previously. For some two months she had complained of a troublesome cough without expectoration, and shortness of breath which was greatly aggravated by cold air. About twenty-five years ago she had influenza

severely on three occasions in successive years, without any subsequent pulmonary symptoms. Her mother died of 'bronchitis', and a sister of pulmonary tuberculosis.

On examination, the respirations were 24 to 28 per minute, but there was marked dyspnœa on the least exertion. The right lung was normal except for a few scattered rhonchi. The left side of the chest was flattened slightly and its mobility impaired. There was absolute dullness on percussion over the whole of the left lung except at the apex, which was slightly resonant. Breath and voice sounds were very much diminished. The heart was normal and apparently not displaced. There was some arteriosclerosis. All other organs were normal.

On screening, there was almost complete opacity of the left pleural sac. The apex of the left lung was dull, but not completely obscured. A film taken at the same time showed an almost complete opacity of the left chest, suggesting an extensive pleural effusion. The ribs on the left side lay more obliquely, and the intercostal spaces were narrower, than on the right. The mediastinal shadow extended slightly to the right.

A leucocyte count of the blood gave 22,000 leucocytes, 80 per cent of which were polymorphonuclear cells. Paracentesis thoracis was then performed and three pints of serous fluid were withdrawn. The centrifugalized deposit consisted of red blood-corpuscles and leucocytes. A diagnosis of primary pulmonary neoplasm was made.

The pleural cavity rapidly refilled, and on Feb. 9 paracentesis yielded 1 pint 6 oz. of a clear serous fluid containing red blood-corpuscles and numerous lymphocytes. The lung signs remained very similar until Feb. 13, when paracentesis again yielded 1 pint 15 oz. of clear fluid of a similar character. At this time a small enlarged gland was palpated below the outer half of the left clavicle ; no other enlarged glands were observed. The Wassermann was negative, and further examination by X rays recorded no change in the appearance of the thorax. On Feb. 17 laryngoscopic examination revealed complete paralysis of the left vocal cord ; at this time there was evidence of pressure on the left sympathetic. On Feb. 28 there were numerous rhonchi all over the whole of the right lung, with signs of some œdema of the base. The left lung remained unchanged. The patient became rapidly worse ; the temperature varied between 97° and 99°, the pulse rose to between 100 and 110, and the respirations to between 30 and 40. There was no sputum, but a persistent and troublesome cough which caused her much distress. She rapidly sank, and died on March 9, twelve weeks after the first onset of symptoms necessitating medical attention.

Autopsy.—The body was emaciated. In front of the neck of the first rib on the left side was a hard mass of new growth which had involved the sympathetic trunk. On removing the thoracic contents, the left lung was found to be adherent along the bodies of adjacent vertebræ, but had not eroded them. Opposite the 5th rib in front, the left side of the diaphragm was transversely adherent to the chest wall ; below that point it was thickened and universally adherent. The right pleura and lung were normal except for a few small scars of tuberculosis at the apex. The left pleural cavity contained a blood-stained fluid. The parietal pleura was thickened, and coloured blue and white, suggesting patchy areas of new growth and chronic œdema. Under the parietal pleura the new growth was one-third of an inch thick in places. The left dome of the diaphragm formed a firm table and was quite inextensible. The left lung was completely collapsed and densely adherent to the mediastinum. There were fingerlike adhesions between the lung and the parietal pleura, at the apex, laterally between the 3rd and 5th ribs, and at the base to the pericardium and diaphragm. A few enlarged glands were found in the neighbourhood of the bifurcation of the trachea and the hilus of the left lung. The pericardium was infiltrated with new growth on the left side. Both the left recurrent laryngeal and phrenic nerves were surrounded with growth. The heart and other organs were normal, and no further metastases were observed.

Macroscopic Appearance of the Left Lung on Dissection.—The lung was completely collapsed, with a small dense patch, pale yellow in appearance, situated on the pleura at the apex. The bronchi were distinctly thickened, their lumen narrowed uniformly, and filled with blood-tinged mucus. There was no evidence of any localized tumour in the lung substance.

Microscopical Sections.—These, made from the left lung and elsewhere, showed that the carcinoma had a very similar alveolar arrangement of columnar cells, each alveolus containing cells spheroidal or columnar in type, which in some instances lined the walls of the alveoli with a layer one or more cells thick, but in other cases the cells had become detached and lay free in the cavity. The columnar character of the cells was most definite in those places where there was a single layer of cells lining the walls. The alveoli varied much in size, and in places it was difficult to make out any organized arrangement of the tumour cells. The stroma was composed of fibrous tissue, which was variable in amount.

A section of the main lower bronchus showed very marked thickening of the submucosa due to infiltration with carcinoma, and the peribronchial lymphatics were filled with carcinoma cells. Where the bronchial epithelium remained intact, normal columnar ciliated epithelium was seen.

Sections of mediastinal glands and parietal pleura showed new growth with the same characteristics as in the primary lesion.

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RHABDOMYOMA OF THE UVULA: WITH A COLLECTION OF CASES OF RHABDOMYOMA.

By C. NICORY, London.

Although tumours consisting of non-striated muscle (leiomyomata) are common in the uterine wall, and very occasionally appear in the ovary, prostate, and intestinal wall, growths of striped muscle are extremely rare. Rhabdomyoma was first classified as a distinct tumour by Rokitansky,[1] who described such a growth of the testicle—possibly, teratomatous.

Two types of simple rhabdomyoma have been described: one in which the cells tend to differentiate into striated cardiac muscle, and another in which the cells assume the skeletal muscle type. Rhabdomyomata of cardiac muscle are very rare, only 12 cases being on record.[2] They are congenital, often multiple, confined to the heart, and do not infiltrate or give rise to metastases. They are said to be always associated with abnormalities of the central nervous system, usually diffuse sclerosis of the cerebral cortex. Rhabdomyomata of skeletal muscle-cell type hardly ever get beyond the embryonic stage of development. In the slowly growing tumours fully developed muscle fibres are formed; but in the rapidly growing ones the cells are spindle-shaped, and each contains a single nucleus.[3] Rhabdomyomata usually have an abundant content of glycogen.[4]

New growths of the uvula are rare, with the exception of papilloma, which may be sessile or pedunculated. Other tumours which have been met with include angioma, mucous polypus, and primary carcinoma.[5] A rhabdomyoma of the uvula is unique, so far as I have been able to ascertain.

The uvula is composed chiefly of a mass of racemose glands and connective tissue, covered by mucous membrane, and containing a slender prolongation of the azygos uvulæ muscle in its upper part.

The tumour in the present case occurred in a well-nourished girl, age 5. The only antecedent history was some digestive trouble between the ages of six months and one year. On Nov. 7, 1921, the little patient was suffering from an attack of coryza and sore throat. On inspecting the throat the mother observed a swelling on the uvula, about the size of a small marble (4 mm. in diameter), which on further inspection proved to be increasing in size fairly rapidly.

The child was seen by me on Dec. 15, 1921. Examination of the throat revealed a round tumour about the size of a cherry (2 cm. in diameter), attached to the uvula, which appeared like a thin peduncle connecting the growth to the soft palate. The peduncle was so slender that I feared spontaneous detachment with the risk of laryngeal obstruction. On palpation, the tumour was fairly hard and painless. Dysphagia was not complained of, but on two occasions the child became very cyanosed during sleep. Lymphatic glandular enlargement was not detected. A thorough general examination revealed nothing.

Under general anæsthesia the growth was excised by cutting through the base of the uvula.

THE SPECIMEN.—Macroscopically, the neoplasm was of a pale-pink colour, and looked very much like an ordinary tonsil, being beset with small depressions like the crypts of the latter. On section, a fine close striation could be discerned with the naked eye, due to the muscle fibres of which it is largely composed.

Histological Report by Professor Shattock.—The sections show a highly cellular sarcomatous basis, in which are distributed groups of large sarcoblasts, round or slightly polygonal in form, and many with more than a single nucleus. The cytoplasm of these is finally granular (*Fig.* 146). The sarcoblasts pass into slender elongated fibres tapering at the ends and slightly undulating; the fibres tend to

FIG. 146.—Section of rhabdomyoma of uvula. Showing rounded or polygonal sarcoblasts lying in a sarcomatous basis: some of the sarcoblasts have elongated into slender fibres, of which a few are distinctly cross-striated. The muscular elements are stained with Congo red. ($\frac{1}{8}$ obj., slightly reduced.)

run in parallel strands. No fully developed fibres of normal dimensions are present, though some are distinctly transversely striated. Some of the thicker have the peculiar uneven contour such as accompanies muscular contraction. The sarcoblasts vary in size; in some spots they are thickly aggregated in the sarcomatous basis. The muscular elements are readily distinguishable by their copper-red coloration with Congo red; the normal muscle fibres beyond the growth are similarly stained.

The growth recurred as a small nodule in the soft palate, at the base of the excised uvula, and seven months later had invaded the greater part of the right side of the soft palate.

In the literature on rhabdomyoma I find three cases recorded in the lower animals—in a horse,[6] in a codfish,[7] and in a red lake trout.[8] As routine microscopical examination of tumours in animals is much less frequent than in the human subject, I think I am right in assuming that such tumours may be more frequent in animals than in man.

The case described in a three-year-old-horse by Coyne and Cavalié occurred in the region of the mastoido-humeral muscle. The growth was pedunculated, mushroom-shaped, and surrounded by a fibrous capsule. Microscopical examination showed that the tumour was composed almost entirely of muscle fibres, arranged in fasciculi radiating outwards from the base of the peduncle, to be inserted in the fibrous capsule.

The authors divided the area between the peduncle and the periphery of the mushroom-shaped growth into four zones. Commencing nearest the pedicle, the neoplasm was composed of connective tissue pervaded by thick-walled blood-vessels. Further away the fibres of the connective tissue assumed a parallel arrangement, and elongated, rectangular, multinucleated cells were seen, which appeared to be formed by the union of several cells. Coyne and Cavalié assumed that these were " connective-tissue cells " which had commenced transforming into striated muscle. To them they gave the name of 'éléments myogènes'. In these multinucleated cells early protoplasmic changes were observed.

Formation of transversely striated muscle fibres, showing typical staining affinities, was noticed in the central protoplasm, with a corresponding pushing of the nuclei towards the periphery. At first these fibres were devoid of sarcolemma; but, as they increased in length and thickness, a definite sarcolemma made its appearance. Further towards the periphery, they described an intermediate zone consisting of fibres in the various stages of development. In the third, or zone of complete development, fibres which have reached maturity are intermingled with smaller fibres whose development has become arrested, and others showing disappearance of the transverse striation, and even Zenker's degeneration. Finally comes the zone of regression composed of degenerated fibres and hæmorrhagic infarcts. Coyne and Cavalié attributed the degeneration to compression.

This tumour was benign, and the horse resumed its work after the operation, without recurrence.

In the case described by Professor Fiebiger, of Vienna, in a codfish, the tumours were multiple. The largest was situated in the liver, having obliterated most of the hepatic substance; a second in the connective tissue between the attachments of the pylorus; and a third in the region of the tail. These growths were white in colour, very irregular, showing marked lobulation, but definitely encapsulated.

The third case is that recorded by Adami in a red lake trout. The whole neoplasm was composed of cells of the sarcoblastic type, the majority multinucleated, with a tendency to be elongated, and in parts showing cross-striation.

Two most interesting cases in which trauma was the starting-point were noted by Ludwig Buhl, of München, as long ago as 1863.[9]

A servant girl, age 28, had a fall at the age of 20, and had since complained of backache. On examination, a tumour was found in the region of the lumbar vertebræ. The growth was removed by Professor Nussbaum, the operation being accompanied by very severe hæmorrhage. The pain diminished, only to return a few days later, and was followed by a rapid recurrence of the neoplasm, which, a fortnight after the operation, had reached the dimension of an infant's head, requiring a second excision.

Macroscopically, the tumour was markedly lobulated and extremely vascular. Microscopic examination revealed muscle fibres in a stroma of connective tissue very rich in newly formed blood-vessels. The capillaries ran parallel to the muscle fibres, and were so numerous in places that no room was left for any other tissue between them. These bundles of capillaries were surrounded by a connective tissue rich in nuclei, whose substance varied from a homogeneous colloidal mass to completely formed cells. The nuclei were oblong and packed closely together. Further away, the intervals between the nuclei were considerably increased, each nucleus being surrounded by a granular protoplasm, and giving rise to a round or spindle-shaped cell. The nearer one got to the periphery, the more elongated the cells became, and a transverse striation was noticeable in most, while others showed signs of degeneration.

The second case of Buhl's was that of a man, age 50, who, soon after an injury causing laceration of a few fibres of the pectoralis major muscle, developed a tumour at the site of trauma which attained the size of a head. Fluctuation was present, and on inserting a needle a blood-stained watery fluid was withdrawn, containing a considerable number of large lymphocytes and multinucleated cells of various sizes. The tumour, which was extirpated by Professor Nussbaum, was found to be a cyst subdivided by numerous partitions.

Histological examination of the cyst wall revealed young muscle elements, similar to those described in the first case, which when traced towards the interior showed various stages of development, until a zone was reached containing fibres indistinguishable from those of normal muscle. As the interior of the cyst was neared, the degenerating fibres became more and more numerous, until a zone of complete softening was reached. The partitions were composed of fibrous tissue and muscle substance, in a state of hyaline and fatty degeneration. It appears clear that the cyst was formed by a degeneration of muscular elements. The growth recurred locally three weeks after excision.

Buhl concludes that as a result of a pathological stimulus a muscle can commence proliferating and reproducing its various elements. Buhl has further verified this view from observations on amputation stumps, muscle abscesses, and cases of myositis, in which he noticed a proliferation of the same nature as that observed in rhabdomyomata.

In the Museum of the Royal College of Surgeons of England are two specimens, No. 1420.1 and 1420.2, and in the St. Thomas's Hospital Museum one, No. 2.163, of rhabdomyomata occurring in the urinary bladder of infants, described by Professor S. G. Shattock,[10] who assigns their origin to vagrant sarcoblasts which have been displaced beyond their usual deeper limits into the subepithelial tissue of the bladder from Henle's striated external sphincter.

Brock[1] has collected a number of cases of rhabdomyoma occurring in various parts of the body.

In the embryo, voluntary muscular fibres are developed from embryonic cells of the mesoderm (muscle-plate cells), which become elongated and their nuclei multiplied so as to produce long, slender, multinucleated fusiform or

cylindrical embryonic fibres. It is not quite certain whether, as has usually been supposed, the whole fibre is formed of a single enlarged cell, or whether it may be produced by the joining together end-to-end of a number of cells of the muscle plate so as to produce a syncytium from which the striated fibres make their appearance. New fibres are formed in part by a longitudinal splitting of pre-existing fibres, preceded by a multiplication of nuclei. I have not been able to find any case of rhabdomyoma in which a multiplication of the muscle fibres by longitudinal splitting was noticed.

Although most authorities consider rhabdomyomata to be congenital dislocation tumours,[11] and others regard them as teratomatous growths, the cases recorded by Buhl seem to show definitely that a muscular injury is capable of starting a process of embryonic proliferation, with the production of fibres in all stages of development.

CONCLUSION.

True rhabdomyomata, specially in early life, are probably the result of the inclusion of sarcoblasts in unusual positions; but in certain cases an injury to a normal striated muscle may set up a process of embryonic proliferation, leading to the formation of a rapidly-growing muscular tumour.

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THE PATHOLOGY OF NEOPLASMS OF THE TESTIS.

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Neoplasms of the testis have received considerable attention in the past. and the multiplicity of classifications of these growths has led to much confusion in the terminology. It has been our aim, after a careful study of the pathological features in a number of cases, to offer a simple classification which will include all the types usually met with. We hope by this means to clear up to some extent the uncertainty and confusion which at present exist in this field of pathology.

Malignant disease of the testis is relatively uncommon, and our classification is based on a series of 38 cases of neoplasm of the testis operated upon at the Manchester Royal Infirmary between the years 1908 and 1922; in addition we have collected 7 cases from other sources. The results of microscopical examination have been obtained in 21 specimens, and it is upon these data that the pathological findings are based. Among 38 hospital cases, 34 occurred in the fully-descended testis, 3 were in the abdominal retained testis, and 1 was found in the inguinal canal; of the remaining 7 cases, 4 were in the fully-descended testis, 2 in the abdominal testis, and 1 was in the inguinal canal.

The comparative rarity of malignant growths of the testis is shown by the fact that only 38 cases were found among 57,000 male surgical admissions to the hospital during a period of fifteen years. That is to say, one case occurred in every 1500 male admissions to a large general hospital. It is generally admitted that malignant changes in the imperfectly descended testis are relatively more common than in the normally descended organ. Russell Howard[1] found that out of 57 cases, 9 were in the retained testis. Chevassu[2] encountered 113 scrotal growths and 15 malignant tumours of the retained testis. Coley[3] shows the ratio of malignancy in undescended to descended as 1 to 5·5. In our hospital series, 4 cases out of a total of 38 were in the imperfectly descended testis. It is of interest to note that, during the fifteen years under review, 409 cases of undescended testis were operated upon at the Royal Infirmary, whilst during the same period there was one case of malignant inguinal testis. Tanner[4] and Bulkley[5] both assert that the abdominally retained testis is relatively immune to malignant changes. Our series, however, does not substantiate that opinion. A history of trauma was definitely noted in three cases, and the literature appears to agree that there is a fairly sound basis for ascribing malignant changes in the testis to injury.

In considering the relatively increased frequency of malignant disease in the imperfectly descended organ, it must not be overlooked that the testis, when in the abdomen or inguinal canal, is exposed to certain abnormal

conditions which do not affect the scrotal testis. The testis in the inguinal canal is liable to suffer repeated small injuries from the constant contractions and movements of the abdominal muscles forming the inguinal region; the abdominal testis is exposed to the varying changes in intra-abdominal pressure, and is likely to be compressed when any sudden effort is made. The importance of these factors in an organ already the seat of a disturbed function and embryological defects can, of course, be only a matter for conjecture. It may be noted in this connection that malignant disease of an undescended testis that has been placed in the scrotum at an early age is practically unknown, and that no case of malignancy of the ectopic testis appears to have been recorded so far as we can discover. The relatively increased liability of the imperfectly descended testis to undergo malignant changes may depend on the fact that the organ, influenced by its unusual surroundings, is more susceptible to the effects of minor injuries and compression.

The undescended testis is an atrophic and ill-developed organ, and shows well-marked pathological changes. Such an organ is probably predisposed to malignant change, especially when subjected to constant irritation. For these reasons, therefore, operative treatment on the abdominal or inguinal testis appears always to be advisable.

As regards the gross appearance of those specimens that have come under our notice, we should say that a tumour showing multiple cysts separated by fibrous tissue is probably a teratoma, and this diagnosis would be supported by finding normal gland tissue spread over or at one pole of the cystic area. An encephaloid tumour would suggest a spermatocytoma; whilst a sarcoma appears to the naked eye as a firm, homogeneous, solid growth in which localized hæmorrhagic extravasations may be visible.

There did not appear to be any special predisposition for either side to be affected. The average duration of the disease from the time it was first noticed till operation was undertaken was seven months in this series.

Classification.—In a consideration of the histological nature of new growths of the testis, the confusion which exists can best be summarized by comparing the views of three recent workers on this subject. Tanner,[4] in a series of 101 cases, found all his 97 malignant growths to be carcinomatous. Bulkley[5] considered that of 59 cases of malignant testis, 40 were sarcomatous. Ewing[6] made the statement some years ago that all testis tumours were teratomatous in origin, and he still holds this view with certain reservations.

It is not claimed that the small series of cases which has been collected for this paper is in any way sufficient for a statistical review, but it is considered that the material at our disposal illustrates the common types of neoplasm found in the testis, and will therefore help to stabilize the modern view of the histopathology of testis tumours. There is still a widespread view that a tumour of the testis is more likely than not to be a sarcoma; but our observations, combined with a survey of the recent literature, leads us to the opinion that such type of growth is very rare. That sarcoma does occur cannot be denied, as a purely sarcomatous structure can be seen in 2 specimens of our series of 21 cases; 17 cases are, however, definitely carcinomatous in type, and the remaining 2 are innocent tumours.

Tumours of the testis may be classified as follows :—

I. *Innocent*
1. Teratoma
2. Mixed-cell tumour

II. *Malignant*
1. Carcinomata
   a. Spheroidal-celled carcinoma
   b. Spermatocytoma
   c. Chorion-epithelioma

   (Epithelial tumours, and therefore to be classified under general heading of carcinomata)
2. Sarcoma

Of these types, all are to be found in our series, and it is thought that a description of each type, accompanied by the evidence of microphotographs, will help to clarify the position.

I. INNOCENT TUMOURS.

1. **Teratoma** (Fibrocystic Disease.)—This is the commonest of the histologically innocent growths of the testis. It is generally considered that this tumour arises from a parthenogenetically fertilized generative cell, and thus shows microscopically derivatives from the three primary cell-layers of the embryo: epiblast, mesoblast, and hypoblast.

Macroscopically, this tumour consists of a mass of cystic spaces in the testis varying in size from the limits of visibility to the diameter of a marble. The intercystic portion of the tumour is made up of fibrous tissue, and the combined appearance gave rise to the old name for this growth, 'fibrocystic disease'. A portion of normal testicular tissue can be seen spread over or at one pole of the growth.

Microscopically, as the photographs of a typical specimen show (*Figs* 147, 148, 149, 150), the main mass of the tumour consists of dense fibrous tissue. Two distinct types of cyst are present, lined respectively by squamous and columnar epithelium, thus showing the epiblastic and hypoblastic elements of the growth. In addition to the fibrous tissue, other elements of mesoblastic origin will be seen in patches of involuntary muscle fibres. Nicholson[7] considers that the epiblastic elements tend to predominate in ovarian teratomata, and it is an undoubted fact that in the ovary the cysts are more likely to be lined by squamous epithelium, and that more fully formed epithelial elements such as teeth and hair are more frequently found in them. The cysts in the ovarian tumour also tend to become much larger.

There seems no reason to doubt, both from clinical and microscopic evidence, that these innocent tumours may at any time become histologically malignant, the malignant change taking place in any or all of the primitive elements. Consequently such a tumour may show malignancy, becoming a squamous- or columnar-celled carcinoma, a sarcoma, or a mixed carcino-sarcoma. Malignant degeneration of the mesothelial elements is extremely rare, and some authorities deny its possibility.

It also seems probable that a teratoma, while histologically innocent, may show metastasis in distant parts of the body. In this connection it is

FIG. 147.—*Teratoma.* Cyst wall lined by stratified squamous epithelium. ($\frac{2}{3}$ obj.)

FIG. 148.—*Teratoma.* Cysts lined by columnar and squamous epithelium. Fibrous-tissue matrix. ($\frac{2}{3}$ obj.)

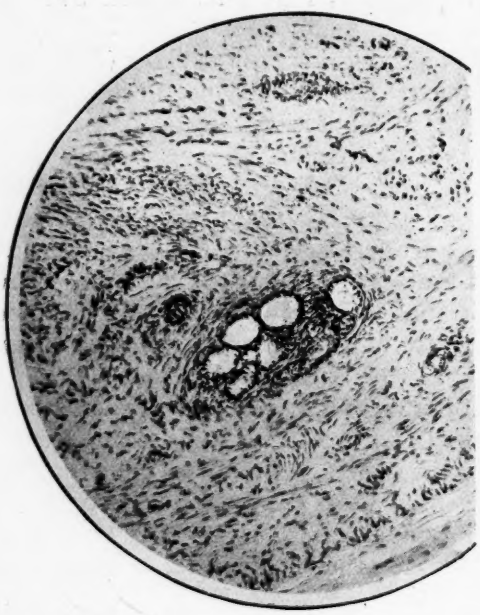

FIG. 149.—*Teratoma.* Primitive adenomatous tissue. Fibrous-tissue matrix. ($\frac{2}{3}$ obj.)

FIG. 150.—*Teratoma.* Involuntary muscle fibres. ($\frac{2}{3}$ obj.)

interesting to note that Nicholson[7] in 1907 was enabled to re-examine Kanthack and Pigg's[8] section of Paget's famous specimen of 'malignant enchondroma of the testis'. His conclusions are that, while cartilage was the principal element of the tumour, epiblastic and hypoblastic epithelium could be found either in the primary growth or in its metastases. The tumour is therefore teratomatous, and metastasis was through the blood-stream by rupture of the growth into a radicle of the spermatic vein. The metastases were histologically innocent in type, and this careful re-examination is of great interest as showing the possibility of metastatic spread of a teratoma.

2. **Mixed-cell Tumour.**—This growth is rare, but as a typical case occurred in this series, the tumour is worthy of description. The neoplasm

FIG. 151.—*Mixed-cell tumour.* A myxomatous area of the growth. ($\frac{2}{3}$ obj.)

FIG. 152.—*Mixed-cell tumour.* Shows areas of hyaline cartilage separated by pavement arrangement of endothelial cells. ($\frac{2}{3}$ obj.)

is identical with the myxo-chondro-endothelioma found so frequently in the parotid gland. A glance at the microphotographs of our specimen (*Figs.* 151, 152) shows very beautifully the three elements of such a growth.

As in the parotid, the tumour is encapsuled, does not form metastases, and, on account of the simplicity of its removal, the prognosis is good. It is of interest to note here that a similar tumour in the parotid cannot be given such a good prognosis, as recurrence is frequent. This appears to be due to the fact that outlying nodules of growth in the parotid tend to break through the fibrous capsule of the main tumour mass and so are apt to be left behind if the tumour is merely enucleated. The introduction of a tube of radium into the tumour bed after enucleation has improved the operative results.

II. MALIGNANT TUMOURS.

Carcinomata.—

a. SPHEROIDAL-CELLED CARCINOMA (*Figs.* 153, 154).—This comes second in frequency of all types of tumour found in the testis. Tanner found 35 per cent of the 101 tumours he recently collected to be of this type. Schultz and Eisendrath[9] give its age-incidence as 26·3 years. These three authors are united in giving this growth the name of embryonal carcinoma, on the assumption that it arises from the malignant degeneration of one or other of the epithelial elements of a teratoma. *Fig.* 153 would seem to support this view. It will be seen that the carcinomatous masses are placed round a cyst lined by one layer of cubical epithelium, and that a cyst lined by

FIG. 153.—*Spheroidal-celled carcinoma.* Masses of infiltrating carcinoma cells arising in relation to a cyst lined by low cuboidal epithelium. A cyst lined by stratified squamous epithelium is also seen in the field. (⅔ obj.)

FIG. 154.—*Spheroidal-celled carcinoma.* 'Scirrhus' type of tumour. Blocks of carcinoma cells in the midst of well-formed fibrous tissue. (⅔ obj.)

squamous epithelium is present in the same microscopic field. These carcinomata are scirrhous in type (*Fig.* 154), the masses of malignant epithelium being placed in the midst of well-formed fibrous tissue.

b. SPERMATOCYTOMA (*Figs.* 155, 156, 157, 158).—This is the most common of all tumours of the testis. In the 101 cases collected by Tanner 62 occurred, and it will be useful to give here Tanner's complete analysis. Of 101 cases 4 were benign, 35 embryonal carcinoma, 62 spermatocytoma. The points of note in these figures are the large preponderance of spermatocytoma, and the complete absence of sarcoma from the series.

The tumour is usefully named, as showing its origin from the germinal 'epithelium'.

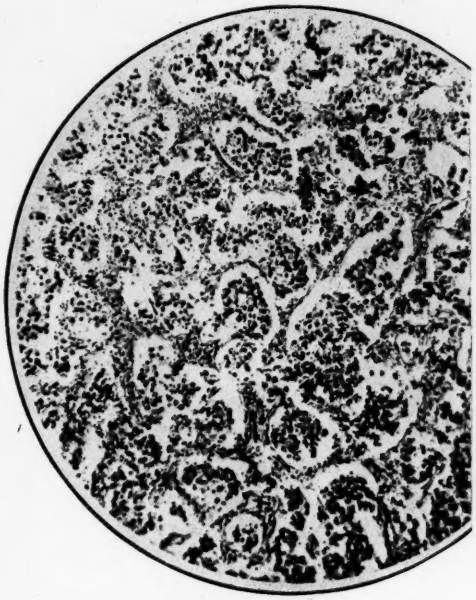

FIG. 155.—*Spermatocytoma.* Shows early stage. Seminiferous tubules packed with proliferated malignant germinal cells, but alveolar arrangement of testis has not yet been completely lost. ($\frac{2}{3}$ obj.)

FIG. 156.—*Spermatocytoma.* No trace of alveoli. Absence of fibrous reticulum. Well-formed blood-vessels. Cf. *Fig.* 160. ($\frac{2}{3}$ obj.)

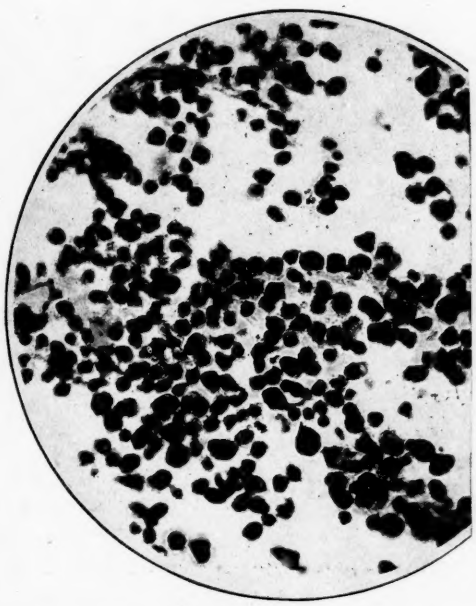

FIG. 157.—*Spermatocytoma.* To show general cell characters of tumour. Large cells with abundant protoplasm. Absence of fibrous reticulum. Cf. *Fig.* 161. ($\frac{1}{6}$ obj.)

FIG. 158.—*Spermatocytoma.* Shows 'encephaloid' nature of tumour. ($\frac{2}{3}$ obj.)

The neoplasm is extremely rapid in its growth, as would be expected in view of the abundant activity of the cell from which it arises. Its age-incidence is later than that of the spheroidal-celled tumour,[9] but is still well within the limits of vigorous sexual activity.

Macroscopically, the growth is encephaloid in type, and from its naked-eye appearance would doubtless in the majority of cases be considered sarcomatous in nature.

Microscopically, however, the tumour is seen to consist of masses of large rounded cells with abundant protoplasm and large, round, well-defined nuclei. The nuclei do not stain as deeply as do those of a sarcoma cell. The cell masses show no supporting reticulum of fine fibrous tissue, the blood-vessels in the tumour are well formed, and few hæmorrhages into the masses of growth can be discovered. An interesting feature is the number of tumour-cells containing eosinophil granules, as this point has been considerably stressed lately in the diagnosis of the carcinoma-cell. The general appearance, therefore, is in all points in favour of a tumour of epithelial origin. One of our sections is valuable as showing the early stage of a spermatocytoma (*Fig.* 155), where the alveolar arrangement of seminiferous tubules has not yet been lost, and the tremendous proliferation of the malignant germinal cells is seen at its site of origin.

It is quite certain that these tumours in the past have been diagnosed as sarcomata, and the main object of this paper is to show as clearly as possible by the proof of the microphotograph that they are epithelial in type and arise from the germinal cells of the seminiferous tubules. It is remarkable, in reviewing the literature of reported 'sarcomas' of the testis, that very few seem to be beyond criticism histologically.

Bulkley[5] reports 40 out of 59 tumours of retained testis as sarcomatous. He had two personal cases, only one of which was examined histologically. He publishes microphotographs of this, and, although areas of the tumour look sarcomatous, there are parts of the growth in which the cells are spermatocyte in type. Grant[10] also publishes microphotographs of an intra-abdominal sarcoma. This tumour, as he acknowledges, also shows carcinomatous areas. It would appear, therefore, that although sarcoma does occur in the testis it is the rarest of all testis tumours, and that the majority of growths formerly diagnosed as sarcoma are epithelial in type and, in view of their place of origin, may conveniently and correctly be classified as spermatocytomata.

c. CHORION-EPITHELIOMA (*Fig.* 159).—Nicholson[7] describes 4 chorion-epitheliomata in his collection of 65 cases. He has found mesoblastic and hypoblastic elements in these tumours as well as the preponderant trophoblast, and he therefore considers them to be essentially teratomata, of which a specialized form of epiblast, the trophoblast, has assumed malignant characters.

The structure is an overgrowth of trophoblast, identical with that found in the malignant hydatidiform mole arising in the placenta.

Our specimen (*Fig.* 159) shows principally an overgrowth of the Langhan's layers of the trophoblast, and occurred in the midst of a teratoma of the testis.

FIG. 159.—*Chorion-epithelioma.* The margin of the cellular growth is shown invading its surrounding fibrous tissue. The cells are of the Langhan's type of trophoblastic epithelium, and among the cell masses are numerous vacuoles. ($\frac{2}{3}$ obj.)

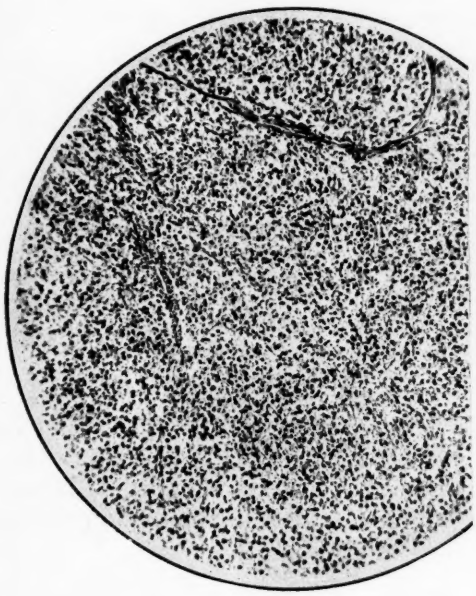

FIG. 160.—*Lymphosarcoma.* Cell elements of tumour smaller than in spermatocytoma. Fine but distinct fibrous reticulum. One small, malformed blood-vessel present in field. ($\frac{2}{3}$ obj.)

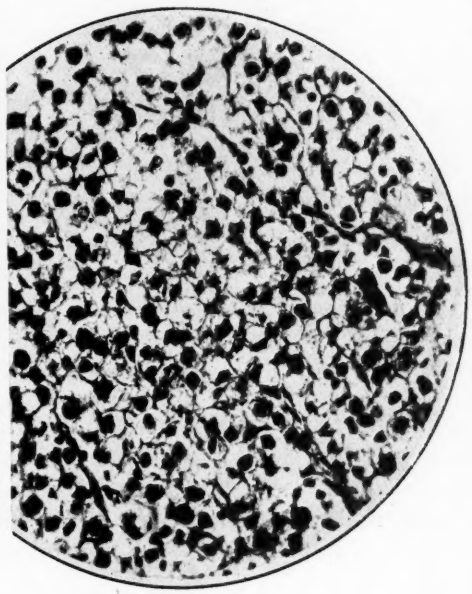

FIG. 161.—*Lymphosarcoma.* Cell nuclei show practically no surrounding protoplasm. Fine fibrous stroma well shown. Cf. *Fig.* 157. ($\frac{1}{6}$ obj.)

Sarcoma.—Two sarcomata are present in this series, and our analysis of the literature makes us consider this to be an unduly large number to find in such a small collection. This is due to our having included a very rare type of growth—a fibrosarcoma. It must be pointed out here that one observer has cast very grave doubts on the authenticity of the lymphosarcoma described below. He considers that the tumour cells are definitely epithelial in type, and would therefore relegate this tumour to the group of spermatocytoma.

a. LYMPHOSARCOMA.—This is probably the common type of sarcoma met with in the testis, and it shows some difficulties in diagnosis from the common spermatocytoma. The distinguishing points are that the cells are small round ones with little cytoplasm and large deeply staining nuclei. The cells are placed in a very definite reticulum of fine fibrous tissue. The vessels of the tumour are numerous and very thin-walled. There are many hæmorrhages into the growth. The microphotographs (*Figs.* 160, 161) make these points clear.

FIG. 162.—*Fibrosarcoma.* Section lightly stained and difficult to photograph. Fibrous-tissue stroma with numerous malignant giant cells. A high-power view showed these cells to contain the typical large, single, multilobed nucleus. (⅔ obj.)

b. FIBROSARCOMA (*Fig.* 162).—This type of tumour is so rarely found in this organ that we have been unable to discover a parallel in the literature. The section of growth shows whorls of spindle-shaped cells, malformed blood-vessels, numerous hæmorrhages into the tumour, and many malignant giant cells with the typical single large multilobed nucleus.

Our thanks are due to Professor Shaw Dunn and Dr. Charles Powell White for their valuable advice and for the loan of microscopic specimens for photography, and to Professor Stopford for permission to prepare the microphotographs in the Anatomical Department of the University of Manchester.

SUMMARY.

1. Malignant disease of the testis is comparatively rare, and occurs about once in 1500 surgical male admissions to hospital.

2. In 45 collected cases, 7 occurred in the imperfectly descended testis.

3. Trauma appears to precede the appearance of malignant changes in certain cases.

4. The commonest malignant tumour of the testis arises in germinal epithelium, and is usefully and accurately described as a spermatocytoma.

5. Sarcoma is an extremely rare tumour of the testis, most of the growths so called being definitely epithelial in type and more correctly classified with the spermatocytomata.

6. True carcinoma of a spheroidal-celled form is frequently found in the testis. It probably arises from a malignant metaplasia of the epiblastic or hypoblastic cell-elements of a teratoma.

7. The age-incidence of carcinoma is 26·3 years, that of spermatocytoma 42·6 years (Schultz and Eisendrath).

8. Teratoma, although histologically innocent, may form metastases, and is extremely liable to malignant change.

9. All tumours of the testis must be considered as potentially malignant growths, and require operative removal as such.

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ARTHROPLASTY.*

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INTRODUCTION AND DEFINITION.

The term arthroplasty in its narrow sense means the reconstruction of a joint damaged by injury or disease, and implies the actual replacement of some of the essential elements of the joint. But in its broader sense it may be taken as meaning the operative mobilization of any stiff joint, and will thus include those types of excision which aim at restoring mobility.

It is quite certain that the free excision of a joint—for example, the hip—will often produce much more functional mobility than a carefully planned reconstruction. It will therefore be necessary to consider closely these two types of mobilization operations in order to determine what are the advantages of the more complicated procedure and under what circumstances it ought to be carried out.

EVIDENCE.

Experimental Evidence.—The most striking experimental evidence of the formation of a joint with its essential structures—capsule, synovial cavity, and articular surfaces—is obtained by the production in an animal of a pseudarthrosis after a fracture of a single bone, such as the femur, and unrestricted mobility of the part appears to be the chief factor in the production of the new joint. There is no interposition of fascia, but the ends of the bone become covered with a layer of fibrocartilage, whilst they are rounded or hollowed so as to form typical joint surfaces. And more remarkable still is the formation of a strong capsular ligament out of mere scar tissue, together with glairy synovial fluid similar to that present in true joints. This affords conclusive proof that all the elements necessary for a joint can be formed *de novo* without any elaborate plastic operation, under the influence of constant movement. But it should be noted further that this pseudarthrosis has always two bad features as compared with the normal joints. In the first place it has an undue mobility, or, in other words, it is a flail-joint quite unsuitable for weight bearing; and secondly it always develops the features of osteo-arthritis in the eburnation of the articular surfaces and the production of hypertrophic fringes or actual loose bodies.

The more elaborate types of experiment in which joints are excised and then re-fashioned are of only limited value in relation to clinical phenomena, because they do not reproduce the diseased conditions which in human surgery precede the operation of arthroplasty. Such experiments merely serve to

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* Read at the sixth meeting of the International Society of Surgery in London on July 18, 1923.

demonstrate how various animal membranes, whether autoplastic or heteroplastic, behave as lining membranes for the new joint.

Foreign membranes, such as those of Cargill or Baer, appear to promote excessive tissue reaction; that is to say, they are attacked by tissue cells, and in the process of their absorption and removal a degree of inflammation is set up which is liable to lead to adhesions in the joint.

As regards the relative value of various autogenous membranes—e.g., fascia, free or pedicled, fat, or muscle—experiment shows that there is not any clear advantage of any one of these over the others. In successful cases the new joint is found to be lined with smooth fibrous tissue; but it is much open to question whether this tissue is really derived from the transplanted membrane or whether it is not the product of the underlying bone, the covering of which has served merely as a temporary limiting membrane.

Clinical Evidence.—The clinical evidence about arthroplasty has accumulated very slowly in this country. This is not due merely to natural conservatism on our part, but also to conflict of evidence about the results of the operation as done elsewhere. This conflict of evidence is not to be discovered so much in the published literature as in the personal exchange of views which takes place in surgical clubs.

Thus ten years ago, after Murphy had described his methods of operative mobilization of the hip- and knee-joints, British surgeons were prepared to give good trial to a method which promised so much. Everyone felt that the operation upon the hip was a less risky proceeding than that upon the knee, and therefore the Murphy operation was tried chiefly upon the former joint; but the results were disappointing rather than encouraging. The operation was one of considerable severity and was accompanied by serious mortality. The majority of those who recovered had only a very limited degree of movement, and the functional result usually tended to get worse with the lapse of time. Therefore the operation has been abandoned by most surgeons, and there have been but few who have felt justified in proceeding to the operation upon the knee. Further, we have been greatly impressed with the slow progress that the operation has made in America itself. Not only has there been a remarkable absence of papers giving late results in consecutive cases, but personal conversation with American surgeons leads one to think that they too have been disappointed and that Murphy's operation upon the hip and knee has few successes to show, but many stiff hips or flail-knees.

Since 1917, however, and especially during recent years, many British surgeons have been led to reconsider their sceptical or hostile attitude in this matter by the work and publications of Professor Putti. In a tentative way special cases have been submitted to operation, and some measure of success has been obtained; but opinion on the whole is undecided both as regards methods, indications, and results.

INDICATIONS.

In general terms arthroplasty is indicated for any ankylosed joint when the function of the limb concerned is seriously impaired and when that impairment may be improved by such mobility as can be attained by the operation.

Thus at the very outset we are faced with the difficulty of deciding beforehand what functional result the operation is likely to produce. Arthroplasty can never create a normal joint, and the average result is a gain in mobility at the expense of strength and precision. In any given case the question is: Will the abnormal joint produced by the arthroplasty be more serviceable than the stiff limb which it is proposed to treat? In answering this question it will be convenient to consider the factors concerned under three headings, namely: (1) *The nature of the causative disease;* (2) *The nature of the disability;* and (3) *The circumstances of the patient.*

1. **The Nature of the Causative Disease.**—The following are the chief conditions which have to be considered:—

a. Trauma	*d.* Tubercle
b. Pyæmia	*e.* Osteo-arthritis
c. Gonorrhœa	*f.* Rheumatoid arthritis.

These causative conditions are arranged in the order of their suitability for treatment by arthroplasty, but such an arrangement requires several qualifying explanations. The ideal condition which promises the best results is complete bony ankylosis with normal bones and muscles, free from infection and pain. Such a condition is more likely to be produced by trauma than by anything else; but it may also arise from pyæmia, gonorrhœa, or tubercle when the disease has long been cured.

The suitability for operation in any such case must be determined by the completion of recovery from the infection and the integrity of the bones and soft parts.

In such a disease as tuberculosis (*Figs.* 163, 164) it is not possible to include or exclude all cases of ankylosis of a given joint in this consideration. The majority are unsuitable because of the latency of the infection and the deep involvement of the bone-ends, but in exceptional cases, where the disease has been almost confined to the synovial membrane, and the bones are dense and firm, a good result may be expected.

A factor of great importance is the condition of the chief muscles which control the joint. If the flexors and extensors are well nourished, free from toxic atrophy or traumatic scarring, then there is good hope of a strong joint resulting from a mobilizing operation. In the knee, for example, the condition of the quadriceps as regards nutrition and freedom from adhesions is the most important indication as to the probable degree of success possible for an arthroplasty.

Figs. 165 and 166 are from a remarkable case illustrating several points. First it will be noted how good is this man's muscular development. He is now able to work in an engineer's shop. He had a bony ankylosis of the elbow resulting from a gunshot wound. At the operation a sequestrum was found lying in a pus cavity, and nothing therefore was done except an excision, and the joint was put up in a plaster cast in full flexion with a window drainage. In spite of a most stormy convalescence, he ultimately made a complete recovery, and serves as a good example of what may sometimes result from a simple excision without any provision of a new lining to the joint.

Osteo-arthritis and rheumatoid arthritis are different from all other conditions under consideration, because they seldom cause bony ankylosis, but are the cause of very crippling pain. The probability of success in such

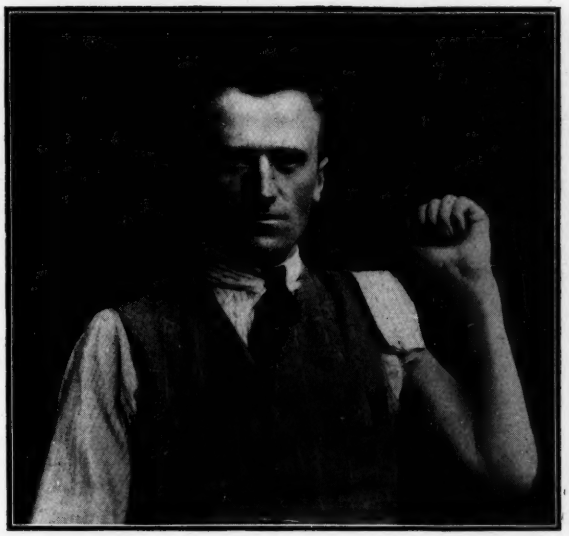

FIG. 163.—Result of arthroplasty by the method described in the text. An officer who had developed a quiet tuberculous ankylosis without any suppuration. Flexion six months after operation.

FIG. 164.—Same case as *Fig.* 163. Extension after operation.

cases will be much less than in the former group, but on the other hand the condition of the patient will be such that he will be content with a smaller degree of improvement. Thus it may be said that ankylosis resulting from

trauma, pyæmia, or gonorrhœa in which infection is at an end, are the best cases for arthroplasty, whilst selected cases of tubercle, osteo-arthritis, and rheumatoid arthritis will also afford a considerable measure of success.

FIG. 165.—Case of traumatic ankylosis in which an excellent result was obtained by simple excision, in spite of violent suppuration.

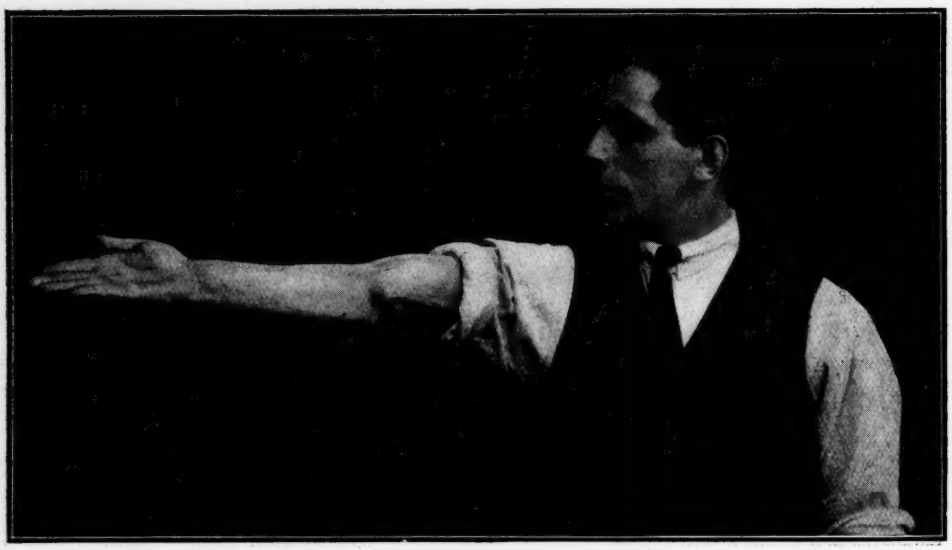

FIG. 166.—Same case as *Fig.* 165, showing voluntary extension.

2. **The Nature of the Functional Impairment.**—Every case of ankylosed joint necessarily implies loss of function, but this loss may be trivial or severe, according to circumstances. If ankylosis has taken place in good position and

is bony and painless, it is better to leave it alone, unless mobility will render it possible for the patient to carry out his occupation which the stiff joint prevents. But if the ankylosis is in bad position; if it is painful, and the deformity progressive so that an operation is imperative, the choice has to be made between operative fixation and operative mobilization. If the joint lesion is multiple, then mobilization of some sort or degree may be imperative. For example, associated ankylosis of the hip and knee on the same leg demands mobilization of the hip, whilst ankylosis of both knees will require that arthroplasty should be done for at least one of the stiff joints.

A sharp distinction must be drawn between the upper and lower limbs as regards the indications for arthroplasty. In the former, mobility is often more important than strength, but in the latter strength and stability are essential and cannot be sacrificed. This is particularly true of the knee-joint, and the opinion in this country still is that bony ankylosis of the knee in good position should not be interfered with, unless it is present on both sides.

3.—**The Circumstances of the Patient.**—A successful result in arthroplasty can only be achieved with the intelligent co-operation of the patient. It is therefore always necessary to take into account those circumstances which will influence this factor of success. The disease or causative condition must be of such long duration that a permanent condition of fixation has been reached, so that it is clear to the patient that the operation is the only alternative to permanent fixation of the joint. Youth is entirely favourable to arthroplasty, only provided that growth of the bones has come to an end. Keen desire for recovery on the part of the patient will be of great assistance in carrying out after-treatment and in obtaining a good result. He must understand the object aimed at and be prepared to do his share in bringing this about. It is useless to operate upon professional invalids or upon workmen who do not want to return to work.

ANALYSIS OF THE PROBLEM.

Before describing methods of arthroplasty in individual joints, it may be well to attempt to analyse the various factors in the problem so that we may assign a proportionate importance to each. For the sake of simplicity we may consider that there are six essentials to be aimed at in the making of a new joint. These are as follows: (1) *To make a sufficient gap between the bone-ends*; (2) *To shape the articular ends*; (3) *To cover the articular ends*; (4) *To provide synovial fluid*; (5) *To provide ligaments and prevent undue mobility*; (6) *To restore function.*

1. **To Make the Gap.**—This must be the first essential of all methods, whether the case is one of bony or of fibrous ankylosis. Enough bone must be removed to allow of free movement in each direction desired, and all possible fibrous tissue, and especially that of inflammatory origin, must be taken away from the site of the new joint. It is usually easier to cut right through the ankylosed joint and then remove what bone and fibrous tissue is necessary from each articular end, rather than to attempt to excise the joint *en bloc.*

The main question here is: How much bone should be removed to obtain a mobile joint? It is obvious that the wider the gap made, the more likely will mobility be secured, but at the same time the greater will be the danger of a flail-joint. In the old days when simple excision was the only form of arthroplasty, the wide removal of the bone was the sole device for securing mobility and preventing re-ankylosis. A consideration of such cases shows that, although free removal of bone and fibrous tissue is always essential, yet it is untrustworthy as the sole guarantee for mobility because of the danger of flail-joint which it involves. Probably the best rule to adopt is to take away enough bone at the time of the operation to allow of the full movement desired, but no more, and to trust to other measures to prevent re-fixation.

2. **To Shape the Articular Ends.**—This is the easiest and most obvious part of the operation. The bone-ends are cut and smoothed by saw, chisel, or file so as to make either a ball-and-socket or a hinge joint. In the latter case, where it is important to avoid a flail-joint, the greatest possible width must be preserved to the articular surfaces. In all cases, whether hinge or socket joint, it is better to shape one surface convex and the other concave, so as to afford more accurate fitting.

3. **To Provide a Covering for the Articular Ends.**—This is the detail of the operation which has been subject to the greatest variation. In simple excision the bones are left to be covered with granulation tissue, and the only factor which prevents the tissue of each surface joining that opposed to it is the width of the gap between the bones. Instead of leaving the bones quite raw, the cut surfaces may be rubbed with hard wax, so as to stop bleeding and to check the exuberance of granulation tissue and ultimately of fibrous tissue.

The chief merit of this procedure is its simplicity, but it is not so efficacious as the use of tissue-flaps. It is, however, a very useful adjunct to other methods. It is often convenient to cover the largest or the convex articular surface with tissue and then to rub wax into the surface of the other articular end. It is well to treat in this manner any raw bone surface which is not efficiently covered by the flap. Tissue-flaps may be of foreign membrane, free fascia from the patient's own tissue, or pedicled flaps of fascia, muscle, or fat. Each has given good results, but the great consensus of opinion is in favour of using free fascia taken from the patient at the time. Foreign membrane excites a certain amount of inflammatory reaction which may cause adhesion.

Pedicled flaps require a much more elaborate operation, and their blood-supply provides for more tissue exudation than occurs from free fascia. Moreover, it is often a matter of some difficulty to get the flap long and mobile enough to give an ample covering.

The fascia lata will always provide all the covering required for lining the largest joint. It probably retains its vitality when transplanted, but there is no excessive tissue reaction. It is important to cover generously all the joint surfaces which have been rawed, and to fix the fascia firmly. For the latter purpose it is convenient to attach the edges of the fascia to the bone itself either by small ivory nails or by sutures passed right through the bones. It is important to understand the exact rôle which is played by the

fascia introduced into the joint. The most it can do is to provide a smooth covering for the bone which will limit the formation of exudation, granulation, and fibrous tissue. It will not necessarily prevent adhesions unless a good gap has been made between the articular surfaces in the first place, and unless efficient means are taken to preserve this gap until the new synovial cavity has been established. Therefore, although good fascial covering of the bone-ends is a great aid towards mobility, it will not by itself ensure it.

4. **To Provide Synovial Fluid and Prevent Adhesions.**—There are two essential conditions necessary for the formation of a new synovial or bursal sac. First, there must be space preserved between the articular surfaces in which serum collects, and secondly, there must be a gliding movement to stimulate the walls of the cavity to secrete a supply of fluid, and to prevent fibrous organization. To attain these two essentials it is necessary to achieve rapid and smooth healing of the wound, and to put up the limb with sufficient traction to keep the bone-ends apart. Movement must be begun early and be carried out by the patient's own muscles aided by counterbalancing or pendulum weights. Attempts to provide an artificial synovia by introducing olive oil or liquid paraffin have not been successful, probably because the wound does not provide a liquid-tight capsule, and the fluid escapes into the tissues. It is very important to secure absolute hæmostasis, because if the joint cavity becomes filled with blood-clot, organization is very likely to take place.

5. **To Provide New Ligaments and Prevent Undue Mobility.**—In dealing with a ball-and-socket joint, such as the hip, which is not subject to much lateral strain, the soft parts surrounding the joint, together with the remains of the original capsule, are generally sufficient to provide ligamentous control of the new joint. But in a joint such as the knee it may be a matter of grave doubt whether this is enough. As judged by published accounts, no part of the reconstruction of the joint has received such little attention as this, yet surely the ligaments are worthy of preservation or construction. In a certain sense the two ideals of mobility and stability in a new joint are opposed to one another; that is to say, certain factors which make for mobility are prejudicial to stability, and vice versa. If extensive removal of bone is the chief factor upon which reliance for a mobile joint is placed, then there will be grave danger of a flail-joint resulting; and, conversely, if in re-making a joint the fear of instability causes a half-hearted resection, then probably only fibrous ankylosis will result. The same opposing ideas concern the treatment of the capsule or its remains as found when the joint is exposed.

To get free painless movement, it is suggested that all the capsular structure should be cut away; but to get a firm joint, as much as possible of the capsule should be preserved.

This really constitutes the crux of the whole problem of arthroplasty—namely, the judicious combination of mobility with stability. It is certainly unjustifiable deliberately to produce a flail-joint or to employ such a wide excision as will probably give rise to it. On the other hand, it is as well to err on the side of over-mobility, because the range of movement usually becomes less with the lapse of time; and in the case of the knee-joint it is quite possible to reconstruct the main ligaments of the joint by a later operation if the stability has been seriously compromised. This would seem

to be a wiser course than that of attempting to construct new ligaments at the time of the main operation. Not only would this unduly prolong the operation, but it would tend to prevent the early achievement of the full movement desired.

6. **To Restore Function.**—The after-treatment is a matter of great importance. It has already been stated that the limb should be slung up with such traction as will serve to keep the joint surfaces apart whilst the new synovial cavity becomes constituted. This keeps the parts at rest without imposing absolute fixation.

When a sufficient time has elapsed for the wound to heal—about eight to ten days—then movements should be begun. The limb is slung in such a manner that no weight is borne by the patient, and then he can move the joint by his own muscles aided by a very little external force.

THE BEST POSSIBLE RESULT IN ARTHROPLASTY.

Before describing methods and results in individual joints, it may be well to ask: What is the best result that arthroplasty can achieve? The best results certainly show joints which are almost functionally perfect; nevertheless they are not normal joints. The evidence for this is of three kinds. In the first place, in many cases such joints have had to be re-opened for one reason or another, and on inspecting the new articulation no one could possibly mistake it for a normal structure (*Fig.* 167). It always presents the appearance of some degree of osteo-arthritis, that is, the surface lacks a smooth covering of cartilage; the edges are heaped up as inflammatory new bone; and the bone-ends are eburnated. An objection to this may be made that these are not the results of arthroplasty, but only the failures. But even the best new joints give evidence of abnormality. They grate on movement, although this grating may be painless; and the X ray shows some degree of lipping at the edges of the articular surfaces. Finally, it is unreasonable to contend that any joint can be normal when the essential element of the articular cartilage is lacking.

FIG. 167.—Bones of elbow-joint three years after arthroplasty, showing marked osteo-arthritis. The bone-ends were cut, shaped, and re-covered successfully with fascia.

SPECIAL JOINTS TO BE CONSIDERED.

It is proposed in the present paper to confine attention to the consideration of three large joints: (1) *The elbow*; (2) *The hip*; and (3) *The knee.*

The temporomaxillary joint is rarely affected, and its treatment does not present any special features. The shoulder-joint is very often affected, but

in this situation arthrodesis affords such an excellent functional result that this fixation operation should be the method of choice in all cases where the scapula is mobile. In regard to the ankle, the choice usually lies between an astragalectomy and amputation. The small joints of the fingers and toes are seldom operated upon, with the exception of the metatarsophalangeal joint of the great toe. This is treated by the excision of the head of the metatarsal and the interposition of a flap from the bursa or soft parts, covering the joint; and such an operation is very satisfactory. In regard to the finger- and thumb-joints, it must be confessed that we have been anything but successful. It is extraordinarily difficult to produce a useful mobile joint in these digits: this is due to two causes. In the first place, the case is regarded as trivial, and due attention is not given to after-treatment; and in the second place, the relation of the extensor tendons to the joint is so intimate that it always becomes adherent to the structure of the reconstituted joint, so that adhesions and fixation are the ultimate result of any arthroplasty.

1. The Elbow.—The elbow is the joint which presents the greatest scope for mobilizing operations. It is not a weight-bearing joint, and its mobility is essential for the carrying out of all occupations of ordinary life and of skilled occupations.

Mobilizing operations have been done for the elbow ever since the advent of aseptic surgery and long before the invention of the term arthroplasty. Until comparatively recently, excision of the joint with a wide removal of bone was the generally-accepted operation of choice, and it was acknowledged to be one which gave a good prospect of success.

The elbow is a joint which very frequently presents a condition of ankylosis which is favourable for a successful arthroplasty. Not only is it frequently the subject of a traumatic ankylosis, but also, when affected by tubercle, the disease is of a mild type and one which readily yields to prolonged fixation, so that the bone-ends remain comparatively healthy. There is, therefore, no difference of opinion as to the advisability of a mobilizing operation being done for the joint in the great majority of cases of ankylosis in adults. The only two exceptions are cases where active inflammatory disease is still present, and cases of labouring men whose arms are fixed in positions in which they carry on their work.

The main question for discussion about the elbow-joint is whether the operation should take the form of a simple excision or whether flaps of soft tissue should be interposed between the bone-ends. It is not possible to give a dogmatic answer to this question, because both methods have given successes and failures. But there would seem to be very good reasons for thinking that the flap method is superior to mere excision. Excision depends for success entirely on the gap between the bones, and there is nothing except this gap to prevent fresh adhesions forming. If the gap is made large enough to make adhesions impossible, then there must be a real danger of producing a flail-joint. It is true that the necessity for a big gap and the danger of adhesions may be lessened by rubbing wax into the cut bone-ends; but this is an uncertain expedient, and reliance upon it will often lead to great limitation of movement.

The usual expedient employed in arthroplasty of the elbow is to shape

a pedicled flap from the tissues *in situ* and to turn this into the joint and fix it by sutures. This, too, is not altogether satisfactory, because it is not always possible to secure a flap adequate to the purpose in the mutilated limbs under consideration. Failure after the pedicled-flap operation is often in the nature of a painful ankylosis, and the reason for this is easy to understand. A flap of soft parts has been turned into the joint and has then undergone adhesion, whilst still retaining vascular and nervous connections with the surrounding structures. So that, whereas after simple excision the patient may be disappointed with the result, inasmuch as he has less movement than he expected, after the pedicled-flap operation he often comes back asking to have the elbow fixed because of the pain he is suffering. But if free flaps of fascia lata are taken, there will be the greatest probability of a mobile and painless joint. Moreover, the amount of fascia obtainable is amply sufficient to provide adequate covering for all three bones concerned in the elbow.

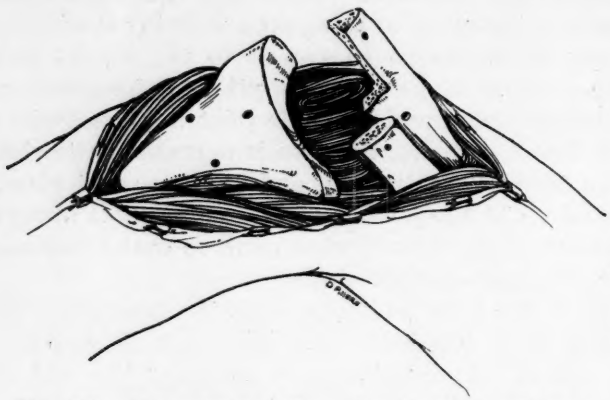

FIG. 168.—Arthroplasty of elbow, showing shaping of bone-ends and drilling of suture-holes.

The steps of the arthroplasty for the elbow-joint are, then, as follows:—

An external curved incision, turning back the skin. The triceps and periosteum are separated from the olecranon by a longitudinal incision, followed by the use of a rugine.

FIG. 169.—Bone-ends covered with fascia.

Separation of the soft parts from the inner condyle of the humerus, with preservation of the ulnar nerve. Division of the bone, usually cutting through the lower end of the humerus. Shaping of the bone-ends. The humerus is shaped like a ∧ with as wide a surface as possible. The olecranon is preserved and its normal surface merely cut out so as to exaggerate the sigmoid notch. The radial head is removed. A careful removal of all the scar tissue round the joint, and especially that containing fragments of bony tissue. The cavity is packed with gauze whilst a piece of fascia lata about six inches long and two and a half inches

wide is taken from the thigh. Suitable pieces of the fascia are wrapped round the three bone-ends so as completely to cover their raw surfaces. In order to afford secure attachment to the bones, the latter are drilled in transverse directions and the fascia is sewn to the bones by kangaroo-tendon sutures passing through these drill-holes (*Figs.* 168, 169). The triceps tendon is sutured over the olecranon and the skin incision closed. The arm is slung to an overhead beam with the elbow at a right angle, the weight of the arm hanging on the hand.

2. **The Hip.**—The hip-joint presents a much more difficult problem than the elbow, both as regards indications for arthroplasty and as to the method of operation.

First, as regards indications. Two distinct conditions have been considered: true bony ankylosis, and the limited painful fixation of osteo-arthritis. In regard to the former, it is evident that double hip-ankylosis or ankylosis of one hip in a faulty position constitute absolute indications for operative interference. In regard to stiff, painful hips, the advisability of operation must be decided by the degree of disability and the vigour of the patient. The matter is complicated by the fact that it is very difficult to produce bony fixation in these painful hips, so that this alternative is not one of practical utility. The sclerosed articular surfaces of osteo-arthritis will not form a firm union, however much their surfaces are removed. There are three conditions in the hip which may call for a mobilizing operation, and each should be treated on special lines. These are: (*a*) *Simple bony ankylosis due to old infection;* (*b*) *Massive ankylosis due to trauma plus infection;* (*c*) *Painful osteo-arthritis and similar conditions.*

a. Simple Ankylosis.—In this condition an osteotomy of the neck will be the first step in the operation. This must then be followed by some procedure for preventing new bony union. A certain amount of bone must be removed by gouging away the head so as to form a shallow cup rounding the distal part of the femoral neck, and then turning in a flap of tissue to cover the latter.

Sir Robert Jones uses a slip cut from the great trochanter which he fixes to the cut surface of the head. Another easy device is to use the capsule which lay in front of the joint as a flap which can be turned back over the neck and sewn to the tissues behind. Both these methods give a useful and permanent degree of mobility.

b. Massive Ankylosis.—When the hip has become solidified by a big mass of bone which has resulted from injury succeeded by sepsis, it is usually wiser to leave the actual site of ankylosis and form a new joint below the line of the trochanter. If the site of the hip-joint itself is re-opened, there will not only be a danger of re-awakening latent sepsis, but the area of bone opened up is so large and vascular that troublesome bleeding takes place and the operation is fraught with great danger to the patient. Recently I have learned this lesson by losing a patient with this condition of massive ankylosis after an arthroplasty. He died within twelve hours of the operation, which itself did not produce any marked degree of shock. He gradually became comatose, with failing pulse—a condition strongly suggestive of fat embolism.

It is wiser, therefore, in such cases to divide the femur below the trochanter, forming the bones in a saddle-shape and turning in a flap of fascia lata, which is very convenient for this purpose.

c. Osteo-arthritis.—For this condition the best operation seems to be a simple excision, removing the diseased bone and rounding the stump of the neck.

The operation is best done by a posterior incision, splitting the fibres of the gluteus maximus, dislocating the head backwards if possible, or cutting off the head first and removing it piecemeal from the acetabulum. It is easy to turn in a flap of soft parts to cover the neck after it has been given a globular form. The posterior approach is not only easier, but it also leaves the strong anterior part of the capsule intact.

The elaborate method of arthroplasty described by Murphy has given disappointing results. It is a severe operation, because of the large bleeding surfaces. The amount of mobility gained by it in the first place is not greater than that obtained by other methods, and the final result is poor.

Whatever method of operation is employed for mobilizing the hip, it is necessary to sling the limb up to an overhead beam, with flexion and abduction of the hip, and to maintain a weight traction of about 20 lb. for the first few weeks until the patient is able to get up.

3. **The Knee.**—In this country mobilizing operations upon ankylosed knees have always been regarded with scepticism. The theoretical and practical difficulties are so great and the results are so uncertain that it is not considered justifiable to advise it as an alternative to a firmly ankylosed knee in good position.

The first essential for the knee-joint is firm stability; there must be no fear of back bending and no marked lateral mobility. This stability in a normal knee depends upon the ligaments, posterior, lateral, and crucial, and of these the lateral and crucial are seriously weakened or actually destroyed by disease or the operation of arthroplasty. Again, a stiff and painless knee is much more useful than a movable knee which is in constant pain. When it is considered how little any arthroplastic joint resembles the healthy articulation and how much more it is like a morbid joint, with characters which vary between those of osteo-arthritis and those of a Charcot's joint, there is ample justification for hesitation in advising this procedure. There are two conditions which justify arthroplasty of the knee, namely, ankylosis of both knees, and ankylosis of one in a position which renders the limb useless for walking. In the latter case the usual course is to do an excision and produce a stiff leg in good position; but if the patient is willing to try for a movable joint, and if he is young and otherwise healthy, it is worth while to do an arthroplasty.

In regard to details of the operation I have but few points to urge. In general I have followed the technique described by Professor Putti. In opening the joint it seems better to divide the quadriceps tendon rather than turn up the tibial tubercle. The quadriceps will usually require to be lengthened, and this is provided for by dividing it in Z shape. In exposing the lower end of the femur all the structures at the sides of the joints are reflected by a careful raising from the surface of the bone, taking even a thin shell of

bone with them so as to preserve the maximum strength for the lateral ligaments of the future joint.

The two bones are shaped so as to resemble their natural contour in a somewhat exaggerated form—that is to say, a deep notch is made between the two condyles of the femur, whilst an upstanding ridge is left on the tibia in place of the tibial spine. A large piece of fascia lata is taken, preferably I think from the thigh of the opposite leg. This must be at least 6 inches long and 3 inches wide. The knee-joint is held open in a flexed position and the fascia is made to cover the lower end of the femur, the back of the capsule, and the upper end of the tibia. The two ends of the fascia thus correspond with the front edges of the articular surfaces of the femur and tibia, whilst the middle of the flap is sewn back to the posterior ligament between the two bones. Here again, it is, I think, of advantage to drill holes in the femur and tibia and to tie the fascia to the edges of the bones by kangaroo tendon.

The limb is put up slung to an overhead beam, the knee being semi-flexed, with a weight extension of about 10 lb. attached to the leg below the knee. This ensures some movement from the very outset, and at the end of a week or ten days, when the wound has healed, active movements are begun with the aid of counterpoising weights. When the patient begins to walk, which is in about one month after the operation, he ought to have an apparatus consisting of a thigh-cage and side-irons jointed at the knee fixed into the boot.

If after from three to six months there persists so much lateral mobility that the patient cannot dispense with the apparatus, then it would seem well worth while to do a second operation for the reinforcement of the lateral ligaments. On the outer side of the joint the iliotibial band can be formed into an excellent supplementary knee ligament, whilst on the inner side the tendons of the gracilis and semitendinosus can be used similarly to make an extra internal lateral ligament.

RESULTS.

For the preparation of this paper, all the surgeons of this country have been requested to furnish the results of their own experience with regard to the three joints concerned. I have had replies from almost all these, and I am greatly indebted to them for their advice and assistance. The great majority, however, state that they do not perform arthroplasty operations; thus the sum total of the material that could be collected is comparatively small, and is presented in the following tables, in which the figures from twenty surgeons are combined with those accruing in my own personal experience.*

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* The results given in the following tables have been made up from figures kindly supplied by the following surgeons, supplemented by those of the author, and to these gentlemen I tender my most grateful thanks: J. E. Adams, W. S. Dickie, H. A. T. Fairbank, J. Fraser, G. R. Girdlestone, T. P. Legg, T. P. McMurray, G. P. Mills, J. Morley, T. P. Noble, R. Ollerenshaw, H. J. Paterson, W. H. C. Romanis, C. Rowntree, A. R. Short, H. Stokes, R. A. Stoney, A. H. Tubby, G. G. Turner, G. E. Waugh.

NUMBER OF CONSECUTIVE CASES IN THE LAST 5 YEARS.

ELBOW	HIP	KNEE	TOTAL
94	69	19	182

CAUSE OF ANKYLOSIS IN THE CASES WHEN THIS COULD BE ASCERTAINED.

	TRAUMA	PYÆMIA	TUBERCLE	GONORRHŒA	OSTEO-ARTHRITIS
Elbow ..	36	9	16	1	2
Hip ..	6	14	11	—	26
Knee ..	—	11	4	—	4
Totals ..	42	34	31	1	32

METHOD OF OPERATION.

	EXCISION		FLAP		FREE FASCIA		FOREIGN MEMBRANE	
	Total	Successes	Total	Successes	Total	Successes	Total	Successes
Elbow	49	21	12	9	19	6	1	1
Hip	24	9	19	5	14	6	—	—
Knee	—	—	8	2	3	1	4	2
Successes	41 per cent		41 per cent		36 per cent			

ULTIMATE RESULTS.

	DEATH	GOOD	FAIR	BAD
Elbow ..	—	46 (49%)	27	8
Hip ..	3	16 (23%)	20	10
Knee ..	—	4 (21%)	4	10

It is clear that figures obtained by correspondence have only a limited value; but on the other hand, the fact that the tables represent the united results of the cases of twenty-one different surgeons gives a value to such

figures as representing the general measure of success obtained in this country. They permit of certain general conclusions :—

1. In regard to the number of operations, the elbow has been most frequently the seat of attack, whilst the knee has only rarely been subject to mobilizing operations.

2. Gonorrhœal arthritis has been a very rare causative condition preceding arthroplasty.

3. Successful functional results have followed excision as frequently as the use of a flap (41 per cent in each case), whereas the use of free fascia has produced a slightly lower proportion of successes (36 per cent).

4. There has been no fatality resulting from the operation except in the case of the hip-joint, where the mortality has been rather over 4 per cent.

5. With regard to ultimate results, these have been best in the elbow (49 per cent), and considerably less favourable in the hip (23 per cent) and knee (21 per cent). Thus, among twenty-one British surgeons during the past five years, the chances of a stiff elbow being made functionally good have been about even with the chances of failure, whereas with the hip and with the knee the chances of improvement have been much less, only about 1 in 4 or 5.

Two facts seem to be proved beyond all doubt. The first is that arthroplasty is capable of producing almost perfect functional joints in the case of the elbow and knee. The second is that the attainment of this perfect result is the exception and not the rule.

So long as arthroplasty can only fashion joints lined by fibrous tissue it is unlikely that these results will be much improved. Probably future achievement lies in the direction of finding some way of replacing the lost articular cartilages by new cartilage grafts.

SUMMARY.

1. Arthroplasty should be defined as an operative procedure upon an ankylosed joint which has the object of restoring mobility.

2. The pseudarthrosis which sometimes results from a simple fracture proves that a new joint can be formed, including fitting articular ends, capsule, and synovia, without any plastic operation.

3. Clinical evidence as to the result of arthroplasty is conflicting. There is ample evidence that operative mobilization of the elbow is usually followed by greatly improved function. Arthroplasties for the hip and knee often lead to disappointment or failure.

4. The condition most favourable for arthroplasty is bony ankylosis due to trauma or pyæmia which has long been cured. Certain cases of tubercle and osteo-arthritis also give good results. The essential act in arthroplasty is to make a gap between the articular ends and to maintain this gap whilst healing takes place. Shaping and covering the articular ends are useful, but not essential. Continuous traction on the new articulation and early voluntary movements are the essentials of after-treatment.

5. In the elbow, the indications include all cases of bony ankylosis free

from active infection, except those in which a strong, useful arm is present in a labouring man. The best operation for the elbow is to preserve the whole width of the humeral condyles and to cover this bone with a free flap of fascia lata.

6. In the hip, three different types of operation must be considered. For simple ankylosis, an osteotomy of the neck of the femur with interposition of a flap taken from the trochanter or from the capsule. For massive hypertrophic ankylosis, a subtrochanteric osteotomy with the interposition of a fascial flap, forming a saddle-shaped joint. For osteo-arthritis, excision of the head of the femur.

7. In the knee, the importance of stability and painlessness makes any mobilizing operation unjustifiable if the joint is fixed in a good position. It is only in the case of ankylosis of both knees that arthroplasty is to be considered. The use of free fascia to cover the lower end of the femur, the preservation of the lateral ligaments, and the use of a jointed knee-cage for some months after operation, are the special points on which stress must be laid. If lateral mobility persists, then the lateral and crucial ligaments must be reinforced by a second operation.

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NOTE.—The above article introduced the subject of Arthroplasty at the International Society of Surgery. A critical summary of the papers and discussion which followed will be found on page 319.

ANOMALIES OF INTESTINAL ROTATION: THEIR EMBRYOLOGY AND SURGICAL ASPECTS: WITH REPORT OF FIVE CASES.

By NORMAN M. DOTT, Edinburgh.

INTRODUCTION.

During its development the abdominal portion of the alimentary canal may suffer a large variety of perversions. We are here concerned with that variety by which the disposition of its parts is interfered with. In the three main subdivisions of the alimentary canal, the incidence of essential errors of disposition is confined almost entirely to the midgut. Error in location or attachment of that part of the foregut situated within the abdomen (stomach and duodenum down to biliary papilla) is excessively rare. Error in location or attachment of the hindgut (left end of transverse colon to rectum) is also uncommon. The splenic flexure is very constant in its location, and in a review of the relative literature I have noted but two instances of gross displacement of this part (Farabœuf,[1] Mascarel[2]). Variations in the course of the descending and sigmoid colons constitute but minor modifications of their normal curves or degree of adhesion. Black[3] has reviewed this subject, and finds only 9 records of cases in which the descending colon erred so far in its course as to reach the mid-line. The sigmoid colon is liable to great variation in length, and hence in position, but its primary attachment is remarkably constant. In the very rare condition of extroversion of the cloaca it may be noted that the hindgut is so maldeveloped as to be almost unrecognizable—it is completely misplaced (Johnston[4]).

In contrast to the rarity of true malposition of the foregut and hindgut, a brief review of the literature has furnished me with 45 records of gross developmental errors in the disposition of the midgut (the intestine from the duodenal papilla to the left third of the transverse colon). The reason for this greater frequency of error in the midgut is to be found in the more complicated evolution of its natural disposition in the abdomen. Minor degrees of developmental misplacement of portions of the midgut are extremely common.

The surgical importance of abnormal situation of the portions of intestine derived from the midgut loop requires little comment. It is of importance to the correct diagnosis of abdominal pathology. Has not left-sided appendicitis been kept under observation, with disastrous consequences, when a normally placed organ would have been removed by timely operation? It is of importance at the exploratory laparotomy. Failure to recognize the nature and characteristic features of these misplacements may lead to grave errors in procedure, or to injurious prolongation of the operation, or to its

abandonment. It is of importance in respect of the pathology it may directly cause. The conditions directly due to gross congenital malposition of the intestines are lack of sufficient adhesion, with consequent tendency to secondary displacements, torsion, and volvulus; and less commonly excessive adhesions, leading to kinking or compression of the bowel.

The difficulties of abdominal diagnosis and of exploratory laparotomy demand special consideration in infants, and the probability of direct pathological consequences of the maldevelopment is greatest in them. The condition therefore acquires an especial significance in regard to the surgery of infancy.

The three cases which have come under my own observation are distinguished by gross errors of the rotation process by which the midgut acquires its typical disposition, and by a secondary pathology leading to acute intestinal obstruction. The first was a case of congenital reversed rotation and deficient peritoneal fixation, which in old age led to torsion, kinking, and acute obstruction of the large intestine. In the second case, non-rotation with deficient peritoneal fixation predisposed to extensive volvulus with acute duodenal obstruction within five days of birth. In the third case, mal-rotation with deficient peritoneal fixation led to extensive volvulus and acute duodenal obstruction within three days of birth.

In reviewing the relative literature, I have selected only those records in which a fundamental error of intestinal rotation was present. Although I fully appreciate their surgical importance, it is not possible to deal here with such conditions as over-descent, undue mobility, and defective descent of the cæcum, undue mobility of the descending colon, excessive length and undue mobility of the sigmoid loop. These conditions represent comparatively slight developmental variations, and their inclusion would entail too comprehensive a field. Complete and partial transposition of the viscera do not concern us here.

A glance over the titles of the records of the appended bibliography demonstrates clearly that there is a lack of uniformity of description and classification of the conditions dependent on fundamental errors of rotation of the midgut loop. It would appear desirable to arrive at some simple and consistent plan of nomenclature and classification. This can best be accomplished by a consideration of the embryology of the conditions, and of their secondary pathology.

EMBRYOLOGY.

The first indication of the alimentary canal is the entodermic vesicle of the zygote. By a constriction the vesicle becomes divided into an intra-embryonic portion—the future alimentary canal and its appendages—and an extra-embryonic portion—the yolk sac; the intervening constriction is the vitello-intestinal duct. As the embryo elongates, the alimentary canal takes the form of a tube, and its subdivisions become apparent.

In *Fig.* 170 the essentials of the abdominal portion of the alimentary tract during the fifth week are schematically represented. The canal is seen to be divided into three main subdivisions, foregut, midgut, and hindgut. The subdivision is based on form: the parts constitute three distinct loops.

It is based on blood-supply: this is distinct for each part, the cœliac axis, superior mesenteric, and inferior mesenteric arteries respectively. It is largely applicable to function: the foregut, digestive; the midgut, absorptive; the hindgut, excretory. All are suspended by the common dorsal mesentery.

The ventral mesentery of the foregut and the allantoic ventral connection of the hindgut do not concern us. The midgut has a ventral attachment, by the vitello-intestinal duct, to the yolk sac; the attachment is lost at an early period.

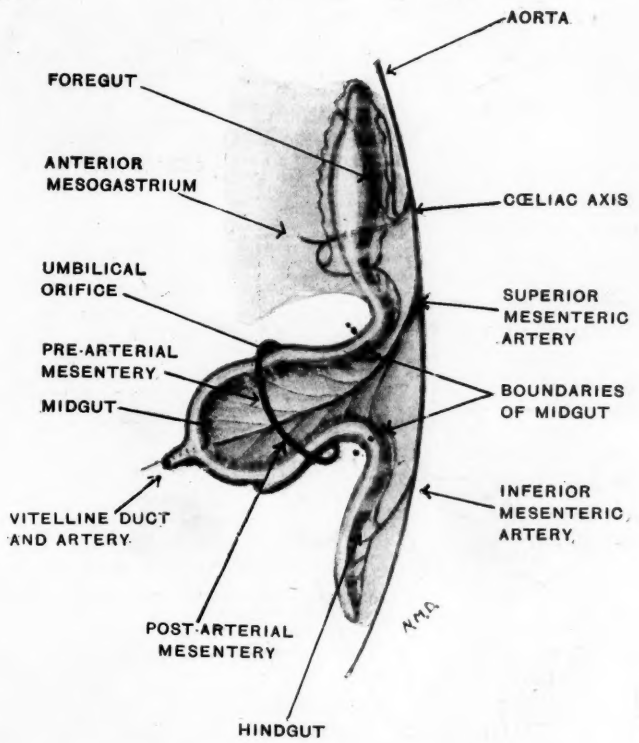

FIG. 170.—Diagram representing conditions of primitive alimentary tract at 5th week. The three main subdivisions are seen to constitute three loops—the foregut, midgut, and hindgut. The aorta is representative of the axis of the body. From it the three loops are suspended by their common mesentery, in the sagittal plane. In the mesentery the special arterial supply for each loop is represented. The midgut loop is already large and has been extruded into the umbilical cord. The cæcal bud is appearing.

For clearness in subsequent figures, the midgut has been coloured yellow, the pre-arterial mesentery green, and the post-arterial mesentery purple.

The abdominal portion of the foregut forms the stomach and the duodenum down to the biliary papilla. As early as the fourth week the bulging of the greater curvature of the stomach appears. The oblique direction and curved form of the organ are the result of its unequal growth. Thus the shape and posture of the stomach depend on intrinsic forces and are very constant. The upper part of the duodenum is deviated to the right by the stomach; its mesentery becomes thickened and shortened, and into the latter the dorsal pancreatic rudiment grows during the fourth week. The position of the

upper part of the duodenum is equally as constant as that of the stomach; the growth of the pancreas into its mesentery is responsible for its curvature and fixation. It will thus be seen that the lower end of the foregut—that is, the duodenum at the level of the biliary papilla—is, at a very early period, a fixed and constant point, a little to the right of the mid-line, from which the midgut loop depends.

At first the hindgut occupies the middle line of the abdomen. From its upper end a 'retention band' (Frazer and Robbins[5]), a mesenchymal thickening in the mesentery, passes upwards to the condensed tissue about

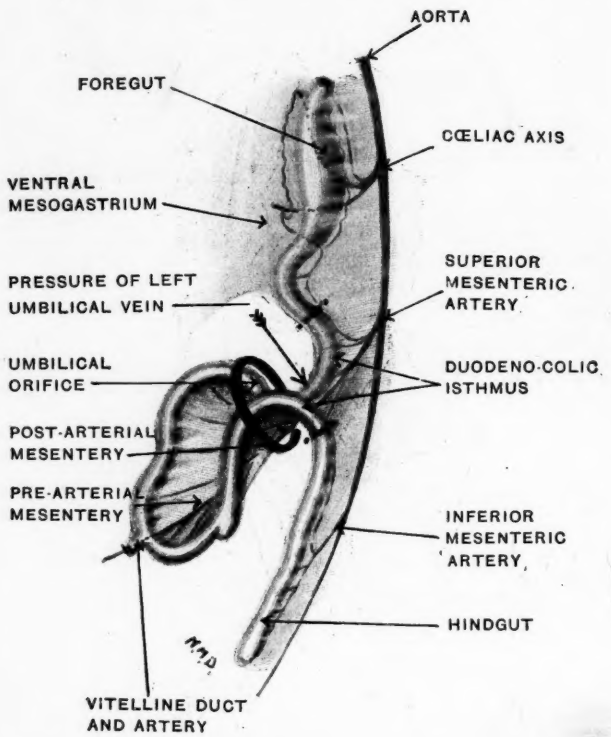

FIG. 171.—Diagram representing conditions of alimentary tract about the 8th week. The first stage of rotation is being accomplished. The arrow indicates the pressure exerted by the left umbilical vein upon the pre-arterial segment of the loop, forcing it downwards and to the right. Note the narrow duodeno-colic isthmus at the base of the loop, with the superior mesenteric artery running through it.

the origin of the superior mesenteric artery. This retention band does not keep pace in growth with the gut or mesentery, so that it forms an anchorage by which the upper end of the hindgut is relatively approximated to the origin of the artery as growth proceeds. The gut, being 'hitched up' by the band, is bent by it at the junction of midgut and hindgut; this flexure is known as the colic angle. The colic angle is, at a very early period, a fixed point at the upper end of the hindgut, from which the midgut loop depends.

It will be noted that the duodenum and colic angle are close to each other, and being fixed points the growth of the embryo causes their relative

approximation, so that they form a narrow isthmus—the duodeno-colic isthmus—to which the two limbs of the midgut loop are attached.

The midgut grows very rapidly in length, and forms a large loop, convex forwards. Already at the fourth week (Mall[6]) the vitello-intestinal duct has lost its connection with the yolk sac and umbilical cord. The rapid growth of the midgut loop and of the liver so diminishes the available abdominal space that the former is extruded into the root of the cord as a temporary and physiological umbilical hernia. At the apex of the herniated loop is the

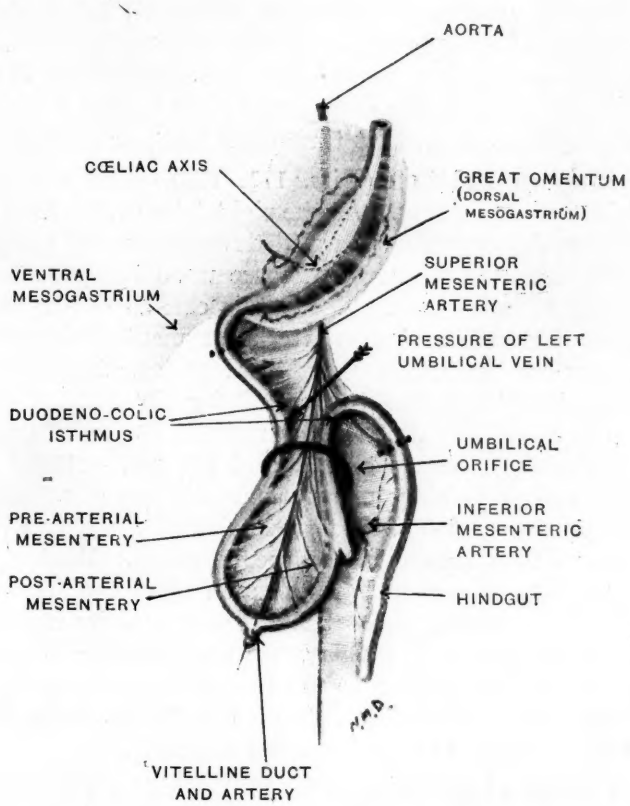

FIG. 172.—Diagram representing the same stage as preceding figure, viewed from ventral aspect. The same points are brought out. Note especially the right-sided position of the small intestine and the left-sided disposition of the large at this early stage of the rotation process. In the condition referred to as 'non-rotation' these relations are maintained.

former site of the vitello-intestinal duct and the termination of the superior mesenteric artery—formerly the right omphalo-mesenteric artery. The vessel runs from the dorsal aorta, between the closely approximated ends of the midgut loop, to its apex; it lies in the mesentery of the loop, and sends branches forwards to its anterior segment and backwards to its posterior segment. The loop still lies in the sagittal plane; its anterior segment is the pre-arterial segment, and its half of the mesentery the pre-arterial mesentery; the posterior segment is the post-arterial segment, and its half of the mesentery

the post-arterial mesentery. During the fifth week the bud for the cæco-appendix appears on the post-arterial segment of the loop.

We have now traced the development of the midgut loop up to the fifth week. It constitutes a loop of bowel projecting forwards in the sagittal plane into the umbilical cord. The base of the loop is narrow and contains the artery of supply between its closely approximated segments. The basal attachment of the pre-arterial segment is slightly to the right of the mid-line on account of its duodenal attachment. We are now in a position to study the rotation of the loop.

The first stage of rotation (Frazer and Robbins[5]) takes place while the loop lies in the umbilical cord, between the fifth and tenth weeks. The second stage occurs mainly during its reduction into the abdomen at the tenth week, and is completed when the cæcum reaches the right loin at the eleventh week. The third stage progresses from that time until birth or a short time after it.

The First Stage of Rotation (*Figs.* 171, 172).—The left umbilical vein persists; the right one disappears. As the right lobe of the liver enlarges and descends, the left umbilical vein is carried downwards and to the right. As it deviates in this direction it exerts pressure upon the pre-arterial segment of the midgut loop near its base. The gut is carried downwards (caudally) and to the right. The pre- and post-arterial segments being placed side by side within the narrow circle of the umbilical orifice, the latter is naturally displaced upwards (cranially) and to the left by the former. The intestine rapidly increases in length, so that there results an **S**-shaped flexure, the pre-arterial segment forming the right half, and the post-arterial the left half (*Fig.* 172). This is the first stage of rotation. Failure of rotation up to this stage occurs only in connection with extroversion of the cloaca, and the term 'non-rotation' refers to a failure in the second stage. During their stay in the umbilical cord, the pre-arterial grows much more rapidly in length than does the post-arterial segment, so that the former and its mesentery become disproportionately elongated. In this way the superior mesenteric artery acquires a relatively closer relation to the post-arterial segment. The cæcum and adjacent colon have meanwhile increased in thickness, and constitute a considerable swelling upon the post-arterial segment.

The Second Stage of Rotation (*Fig.* 173).—About the beginning of the tenth week the midgut loop is returned to the abdominal cavity. Frazer and Robbins point out that it is not possible for the bulky hernial content to return *en masse* through the narrow umbilical orifice. The cæcum especially offers resistance to this passage.* They believe that the pre-arterial segment returns first, in continuity of its length, basal end foremost. *Fig.* 173 represents

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* In support of this view that the cæcum is retained to the last in the hernial sac, Frazer and Robbins (loc. cit., p. 94) refer to Mall's specimen, in which the midgut loop was in process of reduction, only the cæcum remaining in the sac. Further, I note that Sir J. Y. Simpson (*Edin. Med. and Surg. Jour.*, 1839, lii, 19) reported on an anencephalic fœtus of full term, in which the cæcum and a few coils of ileum were retained in a persistent umbilical sac. Hunter (*vide infra*) records a case of great interest in this connection, in which a mesenteric cyst of the jejunum constituted a more formidable obstruction to reduction than did the cæcum. He believes that an inverted order of reduction accounted for the reversed second stage of intestinal rotation.

the small intestine (pre-arterial segment) passing through the umbilical orifice in this way. The cæcum, adjacent ileum, and colon are still in the cord, and they hold with them the termination of the superior mesenteric artery. It will thus be seen that during the return of the small intestine the artery is anchored forward to the umbilicus and is suspended across the abdomen between its origin from the aorta and the umbilicus. The small intestine

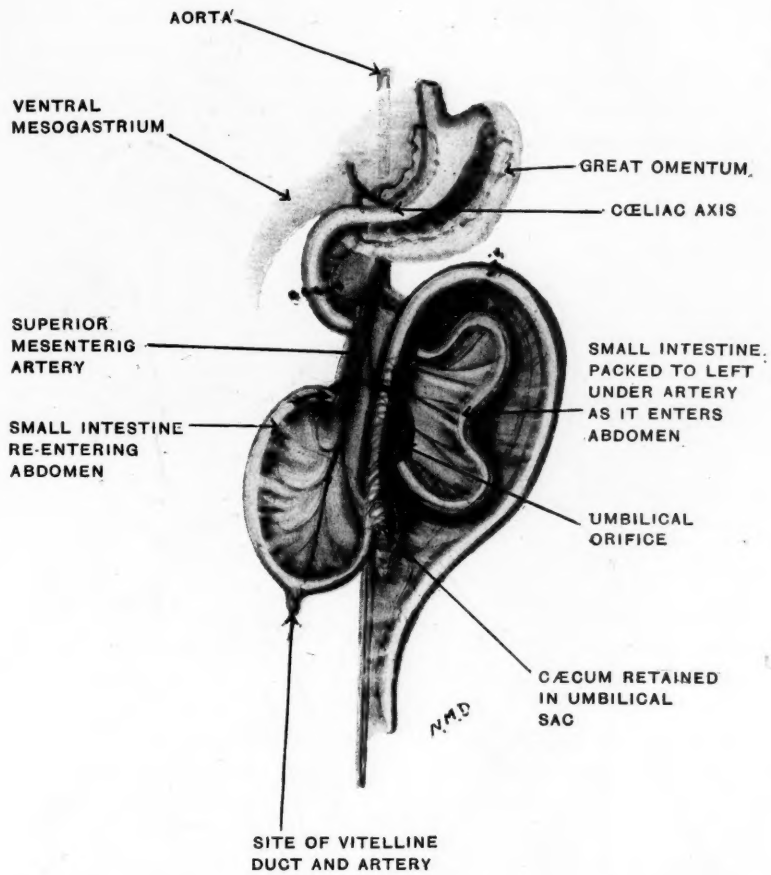

FIG. 173.—Diagram representing conditions of the alimentary tract at the 10th week. It will be seen that the pre-arterial segment of the loop—the small intestine—has increased in length disproportionately to the post-arterial segment, and that its mesentery has shared its rapid growth. The cæcum and adjacent colon have grown relatively thick. The temporary umbilical hernia is in process of reduction. The small intestine is seen entering the abdomen on the right side of the superior mesenteric vessels and passing to the left side of the abdomen behind the mesenteric vessels to fill up the available space. The vessels are held forwards to the umbilicus by the cæcum, which still lies in the sac. The second stage of rotation is in progress.

enters the abdomen on the right side of the artery. As its coils collect within the cavity, those first reduced are pushed into the available space behind the outstretched artery by those following on. The hindgut and its mesentery, which occupy the middle line, are pushed before them—folded to the left and backwards (descending colon). The coils bulge upwards under the colic angle, tending to displace it further up (splenic flexure). The last coil of the ileum

carries the superior mesenteric artery with it as it enters the abdomen. At length the cæcum is reduced. The cæcum now lies free in the region of the umbilicus on a plane anterior to the small intestine and to the mesenteric artery; from here it can pass in any direction. The colon, tending to straighten out, carries the cæcum upwards and to the right. The colon comes to lie

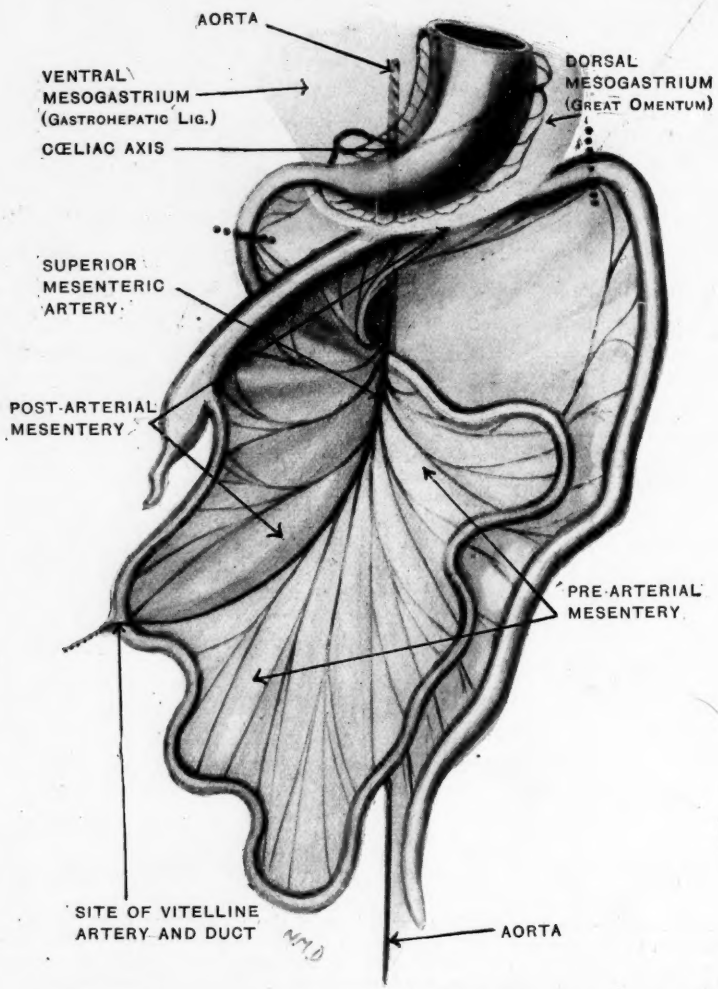

FIG. 174.—Diagram illustrating conditions of alimentary canal about the 11th week. The second stage of rotation is complete—the cæcum is now in contact with the posterior abdominal wall at the right loin. It will now be seen that the midgut loop has rotated on the axis of the superior mesenteric vessels through 270° from its original sagittal plane. The essentials of the permanent disposition of the viscera have been attained.

across the pedicle of the intestinal mass at the origin of the superior mesenteric artery, and the cæcum attains a position below the liver. Elongation of the colon causes the cæcum to descend into the right loin. The second stage of rotation is complete (*Fig.* 174). It will be noted that the ultimate result of the second stage of rotation is an anti-clockwise turn about the axis of the

superior mesenteric artery of 270° from the primitive sagittal position of the loop (not 180° as is often stated). In this way the duodenum is caused to cross behind the superior mesenteric vessels near their origin, while the colon crosses the same point anteriorly. The descending colon has been folded back into the left loin, while the cæcum has attained the right loin. The coils of small intestine range in orderly sequence from the left upper to the right lower regions of the abdomen.

The Third Stage of Rotation.—This stage is characterized by the further descent of the cæcum, and by the fixation of certain portions of the intestine to the posterior abdominal wall by fusion of their mesenteries with the posterior parietal peritoneum. By elongation of the colon the cæcum is caused to descend, so that by the fifth month it has reached the level of the iliac crest. The lower part of the duodenum, having arrived in its retro-arterial position, becomes fixed there by fusion of its mesentery with the posterior parietal peritoneum, and with that of the mesenteric pedicle in front. The duodeno-jejunal flexure is formed and fixed. The superior mesenteric artery is directed towards the right iliac region by the migration of the cæcum to that site. At about the twelfth week the mesentery becomes adherent from above downwards to the posterior abdominal wall along the line of the artery. The area of adhesion spreads out towards the right until the ascending colon and cæcum become quite fixed. Thus that portion of the post-arterial mesentery in relation to the cæcum, ascending colon, and hepatic flexure is entirely obliterated by fusion. The post-arterial mesentery of the transverse colon persists as its mesocolon. To the left of the line of adhesion along the superior mesenteric vessels the pre-arterial mesentery remains free as the mesentery of the small intestine. In this way the line of fusion comes to constitute the wide, obliquely placed root of the mesentery of the small intestine. The mesentery of the hindgut is completely obliterated, from its attachment along the mid-line to the left loin, by fusion with the posterior parietal peritoneum; thus the colon from the splenic flexure to the left iliac region becomes fixed. A free mesentery is, of course, retained at the sigmoid flexure. The practical importance of the third stage lies less in the minor degree of rotation it completes, than in the fixation of the parts in such a way that displacement, and especially torsion and volvulus, are rendered impossible. Thus, the ileocæcal angle is held steady by adhesion of the cæcum and ascending colon. The mass of small intestine, originally dependent from a very narrow pedicle at the origin of the superior mesenteric artery, acquires a wide secondary attachment along the 'root of the mesentery', and is stabilized by it.

DERANGEMENTS OF INTESTINAL ROTATION.

Etiology.—We have seen that the first stage of rotation causes the intestine of the midgut loop to assume an S-shaped distribution, with the small intestine placed to the right of the mid-line, the ileocæcal junction about the mid-line, and the colon entirely to the left. Rotation up to this stage is never interfered with, except in the presence of extroversion of the cloaca.

We have seen that the chief factor which determines the second and essential stage of rotation is the sequence in which the intestine is returned

from the umbilical cord to the abdomen. A departure from this sequence of return is the only possible explanation of perversions of the second stage of rotation. Adhesions, which are sometimes found binding the intestines in their abnormal situations, have been widely credited as the essential cause of their malposition. In view of what we now know of intestinal rotation this view is untenable, for the intestines could only reach their abnormal site while quite mobile and as a result of a disorderly sequence of reduction from the umbilical cord.

What factors may cause a disorderly sequence of return? The normal sequence depends on the bulk of the cæcum retaining it to the last in the hernial sac, while the more easily reduced small intestine enters the abdomen first. The factors which would derange this order are such as would render the small intestine more difficult of reduction or the cæcum easier, or the umbilical orifice so large that they could be reduced with equal facility. I have already cited the remarkable case of Hunter's[7] in which a mesenteric cyst, attached to the jejunum, acted in this way, rendering the small intestine more difficult of reduction. The cases I have to report show no abnormality which could be held responsible, nor is record of such to be found in the literature with the exception of Hunter's case. An unduly wide umbilical orifice would exert no particular restraining influence upon the cæcum, and disorderly reduction might be due to this cause. Evidence as to this possibility is not available, but it seems to be the most probable abnormal factor.

The factors concerned in the third stage of rotation are elongation of the colon, causing descent of the cæcum; and adhesion and obliteration of certain portions of the mesenteries, giving the intestines their natural degree of fixation. The derangements of this stage are of the nature of incomplete development. The cause of failure of completion is quite obscure.

A. **Derangement of the First Stage of Rotation.**—Failure in the first stage of intestinal rotation only occurs in relation to the rare condition of extroversion of the cloaca. In this condition the ureters, genital ducts, and intestinal canal all open on the extroverted area. The ileum usually opens on the surface, and the large intestine is represented only by histological remnants on the extroverted area. A very short intra-abdominal portion of large bowel may be present. The condition is probably due (Johnston[4]) to a rupture of the cloacal membrane at a very early period.

Development of all the structures formed from the primitive gut caudal to the vitello-intestinal duct is interfered with. The post-arterial segment of the midgut loop is therefore involved, and remains quite undeveloped. Rotation cannot occur, and the pre-arterial segment, i.e., the small intestine, retains its primitive position, ventral to the superior mesenteric vessels.

B. **Derangements of the Second Stage of Rotation.**—

Group 1. Non-rotation of the Midgut Loop.—The essential features of this condition are: The small intestine lies chiefly to the right of the mid-line; the duodenum, descending from its normally fixed upper part (foregut), passes down the right side of the superior mesenteric artery. The jejunum and ileum occupy the right hypochondriac, lumbar, and iliac regions; the termination of the ileum may cross the mid-line to reach a left iliac cæcum, or it may terminate about the mid-line in a pelvic cæcum. The colon is confined to

the left side of the abdomen. The cæcum, situate in the pelvis or left iliac region, is reversed, that is, the ileum enters it from the right side. The ascending colon passes upwards from it, usually a short distance to the left of the mid-line, to reach a position behind the greater curvature of the stomach. Between this point and the normally placed splenic flexure a narrow, U-shaped

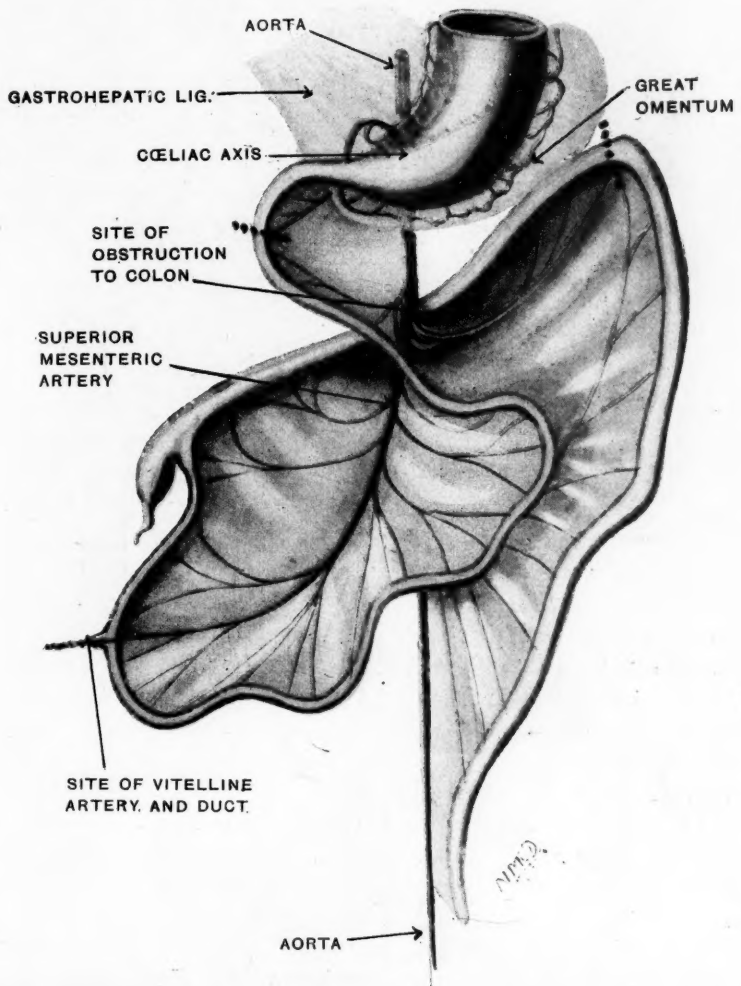

FIG. 175.—Reversed rotation of midgut loop. The midgut loop has rotated in a clockwise direction through 90°, from the original sagittal plane. Thus the colon is brought to lie behind the mesenteric vessels and the duodenum in front of them. These are the only noticeable defects, the viscera otherwise attaining normal positions, though of course their anterior and posterior surfaces are reversed. (*Case* 1.)

loop of transverse colon depends for a variable distance. The relation of the transverse colon to the great omentum is maintained normal. The descending and pelvic colons take their usual course (hindgut).

In these abnormal sites the viscera undergo a great variety of secondary fixation by mesenterial adhesion; the tendency is for fixation to be imperfect.

The duodenum may be adherent at the right side of the mesenteric pedicle, or more or less free. The mesentery may adhere for a variable distance below the origin of the superior mesenteric artery, and the ascending colon may in this way acquire a short mesocolon with its attachment close to the left side of the vertebral column. The cæcum usually remains quite mobile, and is often described as suspended by a free mesentery attached over the lower

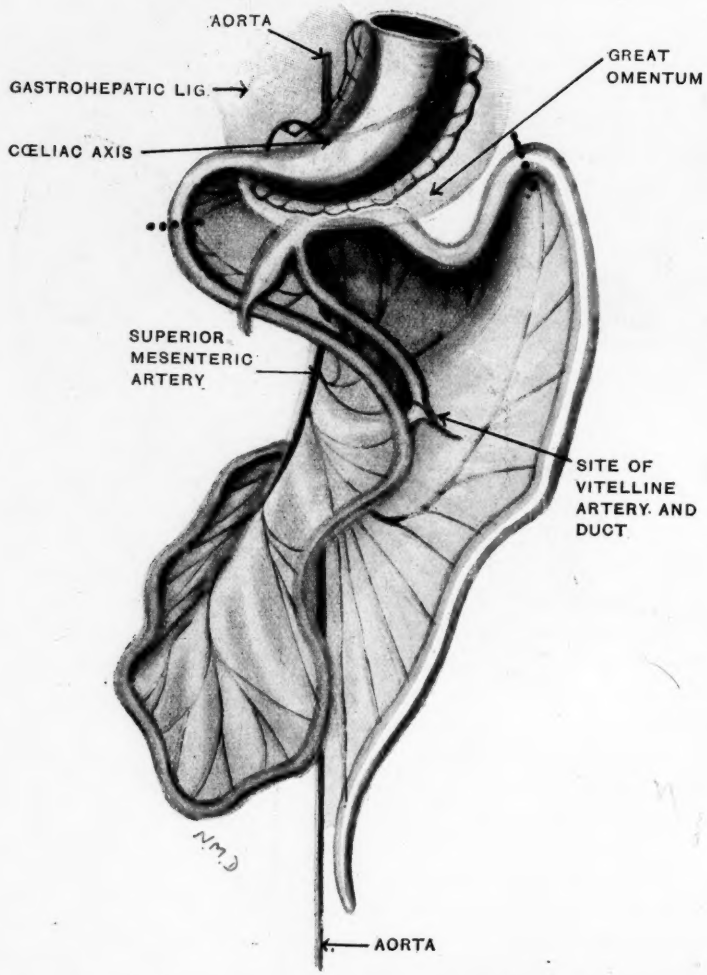

FIG. 176.—Mal-rotation of midgut loop. Reversed rotation of the pre-arterial segment through 90° in a clockwise direction. Arrested rotation of the post-arterial segment. The mesentery is folded over, as on a hinge, at the line of the superior mesenteric artery.

lumbar vertebræ. It may happen, as in the cases of Durante,[8] Clément,[9] Rixford,[10] and the two I report, that no secondary adhesion whatever takes place. In this event, the whole midgut loop, the entire small intestine (except upper duodenum) and proximal half of the colon, remain suspended by an extremely narrow pedicle—the duodeno-colic isthmus of the embryo (*see Fig.* 180).

It appears most likely that the colon and cæcum return first through a lax umbilical ring, carrying with them the lower end of the ileum and superior mesenteric artery. The small intestine immediately following on will not tend to pass behind the artery, since the latter is not now held forwards to the umbilicus, but rather to displace it and the large intestine to the left.

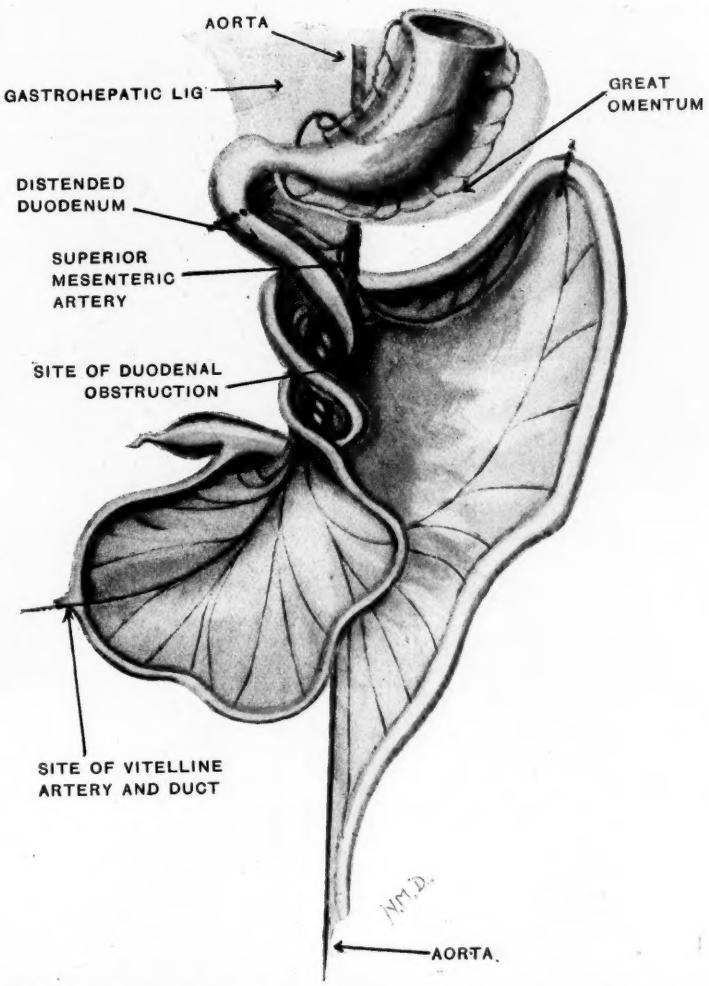

FIG. 177.—Volvulus of midgut loop superimposed on non-rotation. The twist involves one-and-a-quarter turns—450°—in a clockwise direction from the original sagittal plane. That is, it deviates by two complete turns from the normal fully-developed position. Note that the cæcum has attained its normal location. (*Case* 2.)

The following authors record cases of non-rotation: Armstrong,[11] Berry,[12] Blake,[13] Cabot,[14] Cheine,[15] Clément,[9] Corlette,[16] Delatour[17] (2 cases), Descomps,[18] Downes,[19] Fagge,[20] Farabœuf,[1] Huntington[21] (4 cases), Hurst[22] (2 cases), Klopp,[23] Malcolm,[24] Mayo[25] (5 cases), John Reid[26] (2 cases), D. G. Reid,[27] Rixford[10] (3 cases), Schrupp,[28] Simpson,[29] Sturgis,[30] Le Wald[31] (2 cases). Young.[32]

Group 2. Reversed Rotation of the Midgut Loop.—This is a rare condition in which a rotation through 90° takes place in a clockwise direction, so that the transverse colon is brought to cross behind the mesenteric artery close to its origin, and the duodenum crosses the vessel at the same point anteriorly. The intestines, apart from these anomalies, occupy their proper positions, but of course their anterior and posterior surfaces are reversed (*Figs.* 175, 179).

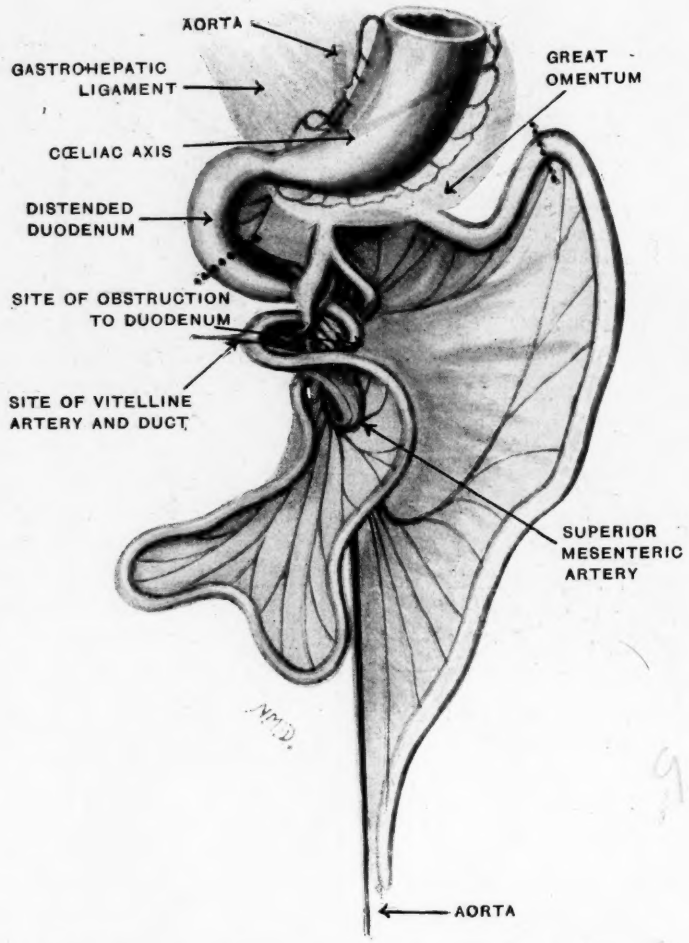

Fig. 178.—Volvulus of the ertire small intestine (excepting duodenum), superimposed on mal-rotation as shown in *Fig.* 176. The twist involves one complete turn of the parts implicated, from the original sagittal plane, in a clockwise direction. (*Case* 3.)

Of this condition I have but two cases to cite, that of Hunter,[7] and one of those I report (*Case* 1). In both of these the mesentery had acquired its usual oblique attachment down to the right iliac fossa, but the ascending colon and cæcum retained a free mesentery, having failed to adhere completely to the posterior abdominal wall. By the adhesion of the mesentery below, the transverse colon was trapped where it passed under the origin of the mesenteric

vessels, and in *Case* 1 (*vide infra*) a narrow but clear tunnel was left for its passage at this site (*see Fig.* 179).

It is clear that the cæcum and colon must have been reduced first from the umbilical cord, probably carrying less ileum with them than in the previous group. The mesenteric vessels, still being held forwards to some extent by their connections with the unreduced pre-arterial segment, permit the cæcum and proximal colon to pass upwards and to the right behind them.

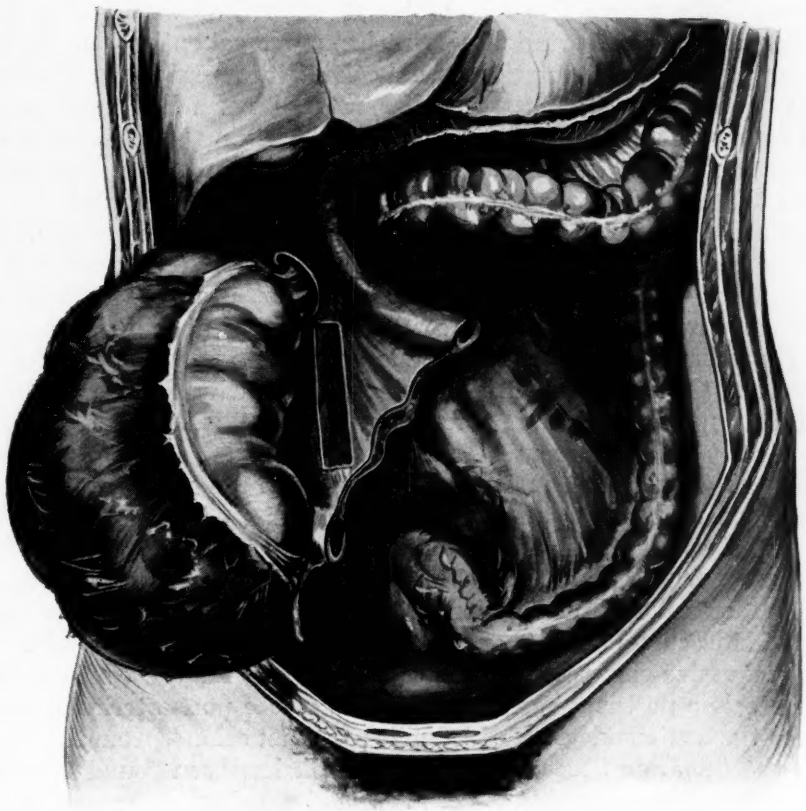

FIG. 179.—*Case* 1. Drawing made from a sketch by the author at the time of operation. Reversed rotation of midgut loop through 90° in a clockwise direction. The transverse colon is seen to cross behind the superior mesenteric vessels; the duodenum crosses in front of them; otherwise the disposition of the viscera appears to be normal. The root of the mesentery of the small intestine (pre-arterial) has acquired its usual secondary attachment to the posterior abdominal wall, except where it crosses the transverse colon. At this point a narrow tunnel has been left for the passage of that viscus. There is a certain degree of mobile cæcum, torsion of which occasioned the kinking and occlusion of the large bowel where it entered the tunnel. Note the enormously distended cæcum, which has ruptured its peritoneal coat.

Group 3. MAL-ROTATION OF THE MIDGUT LOOP.—By this term I intend to imply irregular defects of rotation. In some cases (*Fig.* 177) the pre-arterial segment—the small intestine—passes in front of the vessels, as in reversed rotation. The post-arterial segment—cæcum—also passes in front of the origin of the artery, at which point its further progress to the right has been

arrested by opposition of the misplaced small intestine. The cæcum thus comes to be retained in the subpyloric region.

The cæcum having failed to descend to the right iliac region, and the main trunk of the mesenteric artery remaining turned up on itself, the mesentery does not become adherent to the posterior abdominal wall. The whole of the small intestine, from the middle of the duodenum to the termination of the ileum, remains suspended by the narrow pedicle formed by the mesenteric vessels, the duodenum, and terminal ileum, the last two lying side by side close in front of the vessels (*see Fig.* 178).

In other cases the pre-arterial segment has remained entirely on the right side of the artery, as in non-rotation, or only the first few coils have penetrated behind it; the post-arterial segment has rotated normally, but has been prevented from reaching the posterior abdominal wall in the right iliac region by the unrotated small intestine. The normal fixation of the post-arterial segment on the right side of the abdomen is in this way prevented, and the cæcum and ascending colon retain their complete primitive mesentery.

In these cases the segment of bowel carrying the termination of the mesenteric artery—the lower coil of the ileum—was probably reduced first. The artery early acquiring a position at the back of the abdomen, the viscera subsequently reduced must occupy a plane anterior to it. The exact timing of the return of these viscera will determine their relative disposition.

The following authors record cases of mal-rotation: Barnard,[33] Dezner,[34] Eggers,[35] Lickley and Cameron,[36] Telfer.[37]

I believe that variation in size of the embryonic umbilical orifice is by far the most probable cause of these gross anomalies of the second stage of intestinal rotation.

C. **Derangements of the Third Stage of Rotation.**—Unduly early fixation of the cæcum, or failure in elongation of the colon, causes the various degrees of undescended cæcum—the subhepatic and right lumbar positions. Deficient fixation or excessive elongation of the colon accounts for the over-descended cæcum—the pelvic position. Deficient fixation of the post-arterial mesentery accounts for the various degrees of 'mobile proximal colon', from the sagging cæcum to the 'floating ileocolic segment', which has been found turned up under the spleen (Du Séjours,[38] Voeglein[39]).

THE PATHOLOGICAL CONSEQUENCES OF ANOMALIES OF ROTATION.

Second Stage.—Abnormal disposition of the intestines implies, as shown above, their abnormal attachment and fixation. The abnormal attachments may give rise to no disturbance of function. On the other hand, undue fixation may cause interference with motility, kinks, and compression of the bowel. Lack of efficient fixation predisposes to ptosis, torsion, and volvulus. Of the cases of anomalies of the second stage of rotation which I have collected from the literature, and including the three cases I report below—a total of 48,—35 were accidentally discovered, and the intestinal misplacement apparently gave rise to no symptoms; in 13 cases erroneous fixation of the bowels was the directly predisposing cause of intestinal obstruction. Since so large a proportion of recorded cases have been accidentally discovered, in contrast

to those giving rise to symptoms which prompted examination, it is reasonable to conclude that the numbers of symptomless cases must in reality have a much higher relative incidence. Nevertheless it is also clear that the subject of abnormal intestinal rotation is much more liable to intestinal obstruction from anatomical causes than is the individual whose intestine has attained its proper position.

The sex incidence is about three males to one female.

It is of interest to note the occurrence of symptoms relative to age. Of 13 cases, symptoms developed within a few days of birth in 6, at the age of seventeen years in 1, during adult life in 5, and in old age in 1. It is seen that a relatively high incidence is confined to a very limited period—the first few days of post-natal life. I have reason to believe that this cause of intestinal obstruction in the newly born is not widely recognized, and that its occurrence may be more frequent than is generally supposed.

Of the 13 cases in which obstructive symptoms were present, in 11 insufficient fixation of the intestines, leading to volvulus, was responsible; in 1 undue fixity caused obstruction; in 1 the cause of symptoms was not determined beyond the existence of non-rotation. Volvulus due to imperfect intestinal fixation is by far the most frequent lesion. The predisposing causes of volvulus are: (1) An unduly narrow base to the loop or group of loops of intestine; (2) Undue length of the mesentery; (3) A point of adhesion at the convexity of the loop, which can act as an axis of rotation. The exciting causes are: (1) Unusual effort or accidental movement of the body; (2) The peristaltic motility of the intestine; (3) Undue distention of the intestine. A consideration of these causes elucidates the relative frequency of volvulus in the new-born who are the subjects of anomalies of intestinal rotation.* A predisposing cause, undue narrowness of the attachment of the mesentery, is present at birth. After birth the child moves about more freely, and, as feeding is begun, intestinal motility increases; thus exciting causes are superimposed immediately after birth. In the 5 cases with volvulus at this age, the twist included a very extensive segment of intestine—the whole midgut loop in 4 cases (Durante,[8] Clément,[9] Rixford,[10] *Case* 2 (*Figs.* 177, 180), and the entire small intestine in *Case* 3 (*Figs.* 178, 181)—*vide infra.* In all these cases acute duodenal obstruction was present.

Of the 6 cases in later life, where volvulus was the cause of symptoms, the ileocæcal segment was implicated on 5 occasions. In these cases the congenital failure of fixation of the proximal colon (post-arterial segment) was the predisposing cause. Distention of the cæcum was most probably the exciting cause in 4 of them, while the withdrawal of abdominal packs, after

* The occurrence of volvulus during intra-uterine life has been recorded by Cripps,[40] Pitt,[41] Gessner,[42] Resinelli,[43] and Maxwell.[44] I have reviewed their papers, but am unable to determine with certainty, from the anatomical details given, whether any anomaly of intestinal rotation was present or not. Resinelli's illustration is suggestive of involvement of the whole midgut loop in a volvulus. The severe degree of vascular obstruction which Cripps, Pitt, and Maxwell describe, and the limited extent of the volvulus in their specimens, do not correspond with the type met with in neo-natal cases. The mesentery must have been anatomically imperfect in its formation to permit the occurrence of volvulus; but, with the possible exception of Resinelli's case, I do not think any gross error of intestinal rotation is likely to have been present.

a pelvic operation, produced the twist artificially in 1 case (Rixford[10]); in the sixth individual in whom volvulus was present, the greater part of the small intestine was implicated in a twist of long standing, which only gave rise to symptoms by causing the impaction of a gall-stone in the partially compressed jejunum (Barnard[33]).

The single case of undue fixation of the intestine was one of mal-rotation in a new-born infant; the upper end of the jejunum was obstructed by

FIG. 180.—*Case* 2. Drawing from the post-mortem specimen. Note the duodenum and gall-bladder distended with bile; the site of obstruction of the duodenum where it enters the neck of the volvulus; the tightness with which the duodenum is wound about the mesenteric pedicle, on account of the fixity of its first and second parts. The comparatively wide spiral which the colon describes has occasioned no obstruction. Note the large, free mass of the volvulus and its narrow pedicle. The peculiar form of the transverse colon is typical of the condition of non-rotation of the gut. (*See* diagram, *Fig.* 177).

extensive adhesions and by compression between the misplaced ileum and ascending colon (Denzer[34]).

The case in which the cause of mild obstructive symptoms was not accurately determined was one in which non-rotation was recognized radiologically, but in which operation was not indicated (Hurst[22]).

From these data it appears that failure of efficient intestinal fixation and secondary volvulus is the characteristic pathological consequence of

anomalous intestinal rotation. Further, that volvulus from this cause has its highest incidence within a few days of birth, and that at this time a very extensive volvulus is characteristic. Volvulus of the ileocæcal segment is the typical lesion in later life.

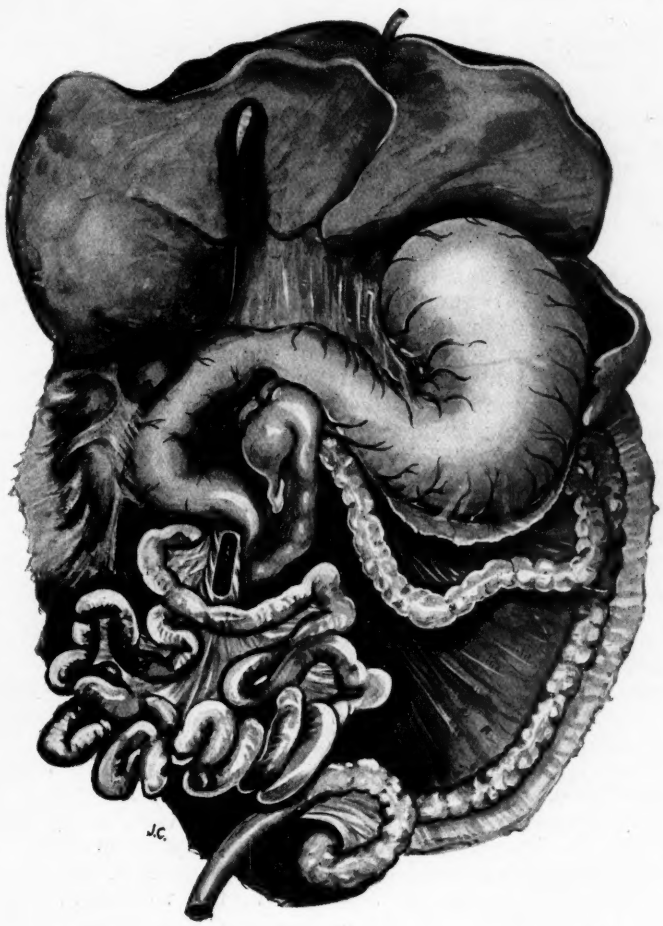

FIG. 181.—*Case* 3. Drawing from the post-mortem specimen. There is a volvulus of the entire small intestine. Note the duodenum distended with bile; the site of the obstruction of the duodenum where it enters the neck of the volvulus; the tightness with which the duodenum is wound about the mesenteric pedicle, on account of the fixation of its first and second parts. The comparatively wide spiral which the ileum describes around the pedicle occasions no obstruction. Note the large, free mass of the volvulus and the narrowness of its pedicle. The cæcum is seen to occupy the subpyloric position, typical of mal-rotation. (*See* diagram, *Fig.* 178.)

Third Stage.—In this connection one has but to mention the important contribution by Waugh[45] on "The morbid consequences of a mobile ascending colon", and the records of Jones,[46] Treves,[47] Ancel and Cavaillon,[48] Voeglein,[39] Du Séjours,[38] and many others, of torsion and volvulus affecting the inefficiently fixed ileocæcal segment.

REPORT OF THREE CASES IN WHICH ANOMALOUS INTESTINAL ROTATION LED TO VOLVULUS WITH ACUTE INTESTINAL OBSTRUCTION.

For permission to make use of the first case I am indebted to Mr. James M. Graham, whom I had the privilege to assist at the operation, on March 15, 1919.

Case 1.—**Reversed rotation of the midgut loop, deficient fixation, volvulus of the cæcum and ascending colon.**

The patient was a spare old man of 68 years, obviously suffering from acute intestinal obstruction. His previous history recorded a similar attack, which had occurred about ten years before. From it he had recovered spontaneously. From that time until three days before we saw him he had enjoyed excellent health.

Three days before examination he had been seized with an acute cramp-like pain in the lower abdomen while out in his fields. The pain caused him to vomit and feel faint, and he took to his bed. The abdominal pain remained fairly continuous and severe; colicky exacerbations recurred at frequent intervals. The vomiting, at first of gastric contents and infrequent, partook later of the regurgitant type and became more frequent. Abdominal distention was noted. There had been complete constipation from the onset of the attack.

On examination, the abdomen was found to be considerably distended all over. The outline of a large and distinct swelling was visible, crossing the mid-line from the upper right to the lower left quadrant. The abdomen was moderately tense and tympanitic all over. The visible swelling was tense, elastic, and tympanitic. It was fixed above and to the right, and could be rocked from side to side below. There was little tenderness, and no evidence of peritoneal infection. External examination revealed no indication of the cause or exact site of the obstruction. The patient's condition on the third day of complete obstruction was indicative of an occlusion of the large bowel, and the visible tumour was recognized as the ballooned cæcum.

Operation.—Immediate operation was undertaken. The abdomen was opened by a right paramedian incision. The enormously distended cæcum at once presented. It was very tense, darkly engorged, and the peritoneal coat had ruptured over its convexity; it seemed about to burst. It was punctured with a hollow needle and gas allowed to escape; this rendered it capable of delivery. We found that the ascending colon and cæcum were possessed of a considerable free mesentery, and had undergone a torsion on their own longitudinal axis of about 180° in a clockwise direction. The gut was so injured by extreme distention, the greater part of its surface being devoid of peritoneum and showing gangrenous patches, that it was thought immediate resection offered the only prospect of recovery. The small intestine was distended and congested. On attempting to define healthy gut beyond the site of volvulus, the colon was found to dive into a tunnel at the back of the abdomen. Further examination demonstrated that the colon, from the hepatic flexure, took a course along the posterior abdominal wall under the mesenteric vessels near their origin (*see Fig.* 179). The transverse colon turned forwards from this position, under cover of the stomach, and occupied its usual site in the left half. The tunnel through which the large intestine passed was just wide enough to accommodate it comfortably; it was a clean-cut passage with smooth, firm walls. The small intestine lay anterior to the colon and the mesenteric vessels. We recognized the condition as some form of developmental malposition. The practical indications were clear. The ileum was divided near the cæcum, and its upper end closed by inversion. The colon was divided on the left side of the tunnel, and its distal segment closed by inversion. The stump of the colon could then be pushed through to the right out of the tunnel, leaving it empty and the colon free. The cæcum and ascending colon were then removed after their mesentery had been secured. Alimentary continuity was re-established by a lateral anastomosis between the lower end of the ileum and the transverse colon. The abdomen was closed.

The operation was particularly difficult on account of the distended intestines, the very unusual anomaly, and the circumstances in which it was conducted. The patient's condition was, however, fairly good at its termination. He succumbed three days later.

No post-mortem examination was made.

I made a sketch of the conditions found at operation at that time, and the literature was consulted, but no record of a similar case could be found. We remained uncertain as to the embryological significance of the condition, until its true nature was more clearly defined by the study of the specimen from *Case* 2. A further search of the literature then brought Hunter's case[7] of reversed rotation to my notice, which confirmed me in my opinions both as to the anatomy and causation of the condition.

Fig. 179 is a drawing from the original sketch made at the time of operation. Note how the colon dives back behind the origin of the mesenteric artery, while the duodenum passes in front. The well-defined orifice of the tunnel for the colon is shown. I would especially emphasize the fact that the general disposition of the viscera appears quite normal.

It is clear that a reversed (clockwise) rotation of the mid-gut loop through 90° had occurred at the second stage of embryonic intestinal rotation, causing the colon to pass behind, and the duodenum in front of, the mesenteric vessels at their origin. During the third stage, the normal adhesion of the mesentery had proceeded down towards the right iliac region, trapping the transverse colon in a tunnel between its original root and the secondarily acquired attachment below. As is so common in cases of perverted rotation, the secondary adhesion of the mesentery had remained incomplete, leaving the cæcum and ascending colon free. Late in life, probably on account of a temporary cæcal distention, volvulus occurred, and was aggravated in its effects by the fixation of the transverse colon in the retro-arterial tunnel.

Cases 2 and 3 occurred in the practice of the Simpson Memorial Maternity Hospital, Edinburgh. I am indebted to Dr. J. A. Douglas, lately Resident Surgeon to that hospital, for notes of their histories. I am indebted to Mr. John Fraser, to whose charge the cases were transferred at the Royal Hospital for Sick Children, for notes of their treatment, and for the specimens from which *Figs.* 180 and 181 were drawn.

Case 2.—**Non-rotation, deficient fixation, volvulus of the entire midgut loop.**

Baby J. W., male, born on Feb. 6, 1923, after a difficult labour and forceps delivery. He appeared to be a normal, healthy baby. Meconium was passed as usual. He was put to the breast, and took his feeds well. The stools were quite normal.

On the fifth day he began to vomit after feeds. Albumen-water and whey were substituted for breast feeding, but were similarly rejected. The vomit early acquired a green colour from admixture of bile. This continued for five days, during which the stools are said to have been normal. On the fifth day of illness a small quantity of blood was seen in the stool. No abdominal distention had been noted. The baby had lost weight. On this day, Feb. 16, he was transmitted to the Royal Hospital for Sick Children.

On admission to the Children's Hospital he was but slightly emaciated; the bowels moved shortly after admission. There was no abdominal distention.

On the sixth day of illness, in spite of careful dieting, vomiting of bile-stained stomach contents continued. It may be worthy of note that regurgitation took place twenty minutes after each feed with regularity.

On the seventh day of illness, emaciation and dehydration were more marked. Vomiting had continued as before. There had been one very small motion. Gastric peristalsis was observed. On these indications, laparotomy was undertaken by Mr. Fraser.

Operation, Feb. 18.—The abdomen was opened by a right paramedian incision through the upper half of the rectus muscle. The distended stomach and upper part of the duodenum presented in the wound. The pylorus was widely dilated, forming but a slight constriction between the dilated viscera on either side. The small intestine was found collapsed but moderately engorged with blood. The transverse colon was identified with difficulty, being unusually deeply situated. The site of obstruction was obviously at the lower part of the duodenum, and it was recognized that some developmental anomaly in disposition of the intestines was responsible. The conditions of the operation did not permit further investigation at the time. The outstanding feature was acute duodenal obstruction, and this condition was relieved by a gastrojejunostomy. The duodenojejunal flexure could not be found, but one of the highest loops of jejunum was selected, approximated to the stomach by the anterior route, and anastomosis carried out. The abdomen was closed.

The child did not rally from his weak and emaciated condition, and died twelve hours later.

Report on Specimen (*Fig.* 180).—The abdominal viscera were fixed *in situ* by formalin injection. At post-mortem examination they were removed entire by stripping them from the posterior abdominal wall.

The anastomosis was in perfect condition; it was undone in order to obtain a clearer view of the viscera.

The liver was normal. The gall-bladder and bile-ducts were considerably distended. The stomach was anatomically normal, but considerably distended. The pylorus was dilated. The great omentum was ill-developed and very short. It was adherent as usual to the transverse colon and mesocolon in their left half, but not to their misplaced right half. The upper part of the duodenum was enormously distended by darkly bile-stained fluid. The first part was normal in its relations and fixation. The second part passed downwards, obliquely from right to left, being dragged towards the middle line at its lower end by its implication in the volvulus. It was attached posteriorly over the right renal vessels, internal to the kidney. Its lower end crossed the mesenteric vessels anteriorly, and, entering the volvulus, spiralled completely round them in a clockwise direction. The site of obstruction was at the point where the duodenum turned sharply round the vessels.

The pancreas was normally disposed, with the exception of the uncinate process (of Winslow). This process formed a little tongue in the mesoduodenum which was attached to the lower part of the duodenal loop, and was drawn across by it in front of the mesenteric vessels. Its extremity entered the volvulus with the duodenum.

The rectum, pelvic colon, descending colon, and splenic flexure were quite normal, and practically empty.

The transverse colon described a narrow U-shaped loop; one limb was attached to the splenic flexure, the other ended below the pylorus, where the colon entered the neck of the volvulus by passing behind the superior mesenteric vessels and spiralling round them. The transverse mesocolon was of normal length, permitting considerable freedom of movement to the loop.

The superior mesenteric artery was normal in origin and was properly distributed, although its relations were disturbed (*vide infra*).

The volvulus implicated the whole of the intestines of the original midgut loop. It involved the entire mass of the small intestine from the second part of the duodenum downwards, the cæcum, ascending colon, and the right half of the transverse colon. It consisted of one and one-quarter turns (450°) in a clockwise direction of the mass of gut mentioned above. The mass was suspended by its narrow pedicle alone, and

was otherwise quite free from fixation. The pedicle, corresponding to the duodeno-colic isthmus of the embryo, was about 1 cm. in thickness, and consisted of the superior mesenteric vessels, the extremities of the midgut segment, and their narrow mesenteries, all twisted together. The duodenum, being fixed at its second part, and tightly wound round the vessels, was occluded by kinking. The colon, being free in its transverse part, was less tightly wound, and described an open spiral round the vessels, which occasioned no obstruction. There was a moderate degree of engorgement of the mesenteric veins, and the intestine of the volvulus showed slight congestion, but nothing approaching strangulation. On examining the isolated mass of intestines, the cæcum was identified on its right and posterior aspect—it had reached its normal site by a devious route, one and a quarter reversed turns. The mesentery formed the central column of the mass, and round it the intestinal coils were clustered.

The twist could be reduced easily by rotating the whole mass of intestines through one and one-quarter turns in an anti-clockwise direction. By this manœuvre the typical conditions of non-rotation were reproduced. The colon was left-sided, and the duodenum, passing down the right side of the mesenteric pedicle, was completely relieved from compression, so that fluid could be propelled through it readily. The lower part of the duodenum was found to be possessed of a short free mesentery.

On rotating the mass further in an anti-clockwise direction, through 270°, the normal disposition of the intestines was attained. The duodenum and uncinate process of the pancreas were drawn into their proper position, behind the origin of the mesenteric vessels, and the former took up this position quite naturally, without any kink or compression. The transverse colon was drawn across the origin of the mesenteric vessels anteriorly, and the ascending colon and cæcum came to occupy the right lumbar and iliac regions. The mesentery was so spread out that, had the cæcum attained this position during life, there appears no reason why the mesentery should not have acquired its normal secondary adhesion and wide root.

From the above facts I conclude that the intestine was in a state of non-rotation at birth, and that, on account of deficient stabilization by secondary adhesion of the mesentery, the midgut mass had undergone a volvulus on its narrow pedicle on the fifth day of post-natal life. The volvulus had probably increased its torsion gradually, inducing a progressive degree of duodenal obstruction, which became complete on the seventh day of illness.

Case 3.—**Mal-rotation, deficient fixation, volvulus of the entire small intestine.**

Baby E. A. W., female, born on Feb. 22, 1923, after a normal labour. The child appeared to be healthy and in every way normal. She was put to the breast and took her feeds well. On the third day of life she began to vomit her feeds. The vomit soon acquired a dark-green colour from the presence of bile. Meconium was passed immediately after birth, and subsequent motions retained the characters of meconium, failing to acquire the normal yellow colour. A rectal lavage, administered on the third day of illness, was returned but slightly stained by meconium. On this day, Feb. 28, she was transferred to the Sick Children's Hospital.

On admission, examination showed that emaciation and dehydration had already proceeded to a very grave degree. The abdomen was considerably distended in its upper part. Gastric peristalsis was easily elicited. Rectal examination demonstrated that a trace of meconium was still present. Shortly after admission she vomited material dark from the presence of altered blood as well as bile. On these indications Mr. Fraser undertook immediate laparotomy.

Operation, Feb. 28.—The abdomen was opened by a right paramedian incision through the upper half of the rectus muscle. The tensely distended stomach presented, and examination revealed a widely dilated pylorus and the upper part of the duodenum also distended. These viscera were deeply congested. The small intestine was collapsed, but engorged with blood. The transverse colon could not be identified. The cæcum and appendix lay just below the pylorus. As in the previous case, acute duodenal obstruction, dependent on a developmental malposition of the intestines, was recognized. The duodenal-jejunal flexure could not be

identified, but a loop of intestine was brought up by the anterior route and a short-circuiting anastomosis carried out. The abdomen was closed.

The child, almost beyond hope of recovery before operation, died seven hours later.

REPORT ON SPECIMEN (*Fig.* 181).—The abdominal viscera were fixed *in situ* by formalin injection, and removed *en masse* at the post-mortem examination.

The anastomosis was undone in order to obtain a clear view of the viscera. The liver, gall-bladder, and bile-ducts were normal. The stomach and first and second parts of the duodenum were normally situated and attached. They were greatly distended, forming a single cavity, which the dilated pylorus encroached upon as a shallow constriction. They were deeply congested, and blood was extensively extravasated into their walls. The great omentum was normal, and was adherent to the anterior surfaces of the transverse colon and mesocolon.

The third part of the duodenum was the site of obstruction. It turned from the second part, which was attached over the right kidney just below its hilum, abruptly forwards, downwards, and to the left, to pass anterior to the mesenteric vessels. From this point it spiralled closely round the mesenteric vessels in a clockwise direction. Its second part being fixed, the duodenum was wound very tightly round the vessels, and was in this way kinked and occluded.

The pancreas was normally situated, except that the uncinate process followed the third part of the duodenum in front of the mesenteric vessels.

The rectum, pelvic and descending colons, and splenic flexure were normal and empty.

The transverse colon was folded into a W-shaped loop, one end attached to the splenic flexure, the other terminating under cover of the pyloric end of the stomach. The transverse mesocolon was very short, so that the intestine was tucked up behind the stomach.

The segment of bowel corresponding to the ascending colon was coiled upon itself in the concavity of the duodenal loop, lying over the head of the pancreas. From it the cæcum projected forwards, its convex surface presenting, while the ileum and appendix were attached to its deep surface. The ileum passed from the cæcum behind the mesenteric vessels, and so entered the neck of the volvulus.

The superior mesenteric artery was normal in origin and in distribution; its relations are considered below.

The volvulus implicated the whole of the small intestine with the exception of the first and second parts of the duodenum. It consisted of one complete turn, in a clockwise direction, of the entire mass of small intestine. The mass was suspended on its narrow twisted pedicle alone, and was otherwise free from fixation. The pedicle, about 1 cm. in thickness, consisted of the superior mesenteric vessels and the closely approximated and parallel duodenum and terminal ileum, the two latter spiralling round the former. The ileum, not being fixed by the mobile cæcum, was wound round the vessels less tightly than was the duodenum, and, taking a wider spiral course, was not obstructed. The veins of the mesentery in the volvulus were engorged with blood, and the intestine showed considerable congestion. The mass of intestine was disposed around the central mesenterial column, as in the previous specimen.

Again I found the twist could be easily reduced to a condition resembling non-rotation by one anti-clockwise turn of the mass; the cæcum, however, still maintained its position below the pylorus. On carrying out a further rotation of the mass in an anti-clockwise direction, through 270°, normal conditions were established, as described in *Case* 2, with the exception that the cæcum could be brought only so far as the right loin, as the colon was unduly short. Reduction of the volvulus entirely relieved the duodenal constriction.

From the above examination, I conclude that the intestines were in a condition of mal-rotation at the time of birth, the duodenum lying in front of the mesenteric pedicle, and the cæcum, arrested by the former, in the subpyloric position. The cæcum having failed to reach the right iliac region and so spread out the mesentery no secondary adhesion of the latter had taken place, and the mass of small intestines

remained suspended by its original narrow pedicle. On the third day of life the mass had undergone volvulus. In this case the duodenal obstruction appears to have been complete from the onset of volvulus. The vascular obstruction was also more severe than in the previous case, but not so complete as to threaten the vitality of the intestine.

ABSTRACT OF PARALLEL CASES FROM THE LITERATURE.

I have noted no case similar to *Case* 1. Volvulus of the ileocæcal segment in cases of anomalies of the third stage of rotation, with simple deficiency of mesenterial fixation, are fairly common, but the retro-arterial position of the colon, signifying reversed rotation, is apparently very rare. In Hunter's[7] case of reversed rotation, the anomaly had no clinical significance; in it a mesenteric cyst caused intestinal obstruction in a new-born child.

Three records of cases of volvulus neonatorum associated with anomalous rotation of the midgut loop have come to my notice, and it may be of interest to recapitulate them briefly.

Durante,[8] in a paper on "Occlusions congénitales de l'Intestin", gives an interesting account of a case of volvulus in a child a few days old, which one recognizes as a torsion of the entire midgut loop, as in *Case* 2.

The child was admitted to hospital within a few days of birth. There were vomiting, hæmatemesis, and melæna. Death occurred on the third day of illness.

Post-mortem examination demonstrated the presence of an extensive volvulus. The volvulus hung on a pedicle, suspended from the point where the duodenum crossed the transverse colon. There was a clockwise twist of one and one-half turns, so that the cæcum was situated on the left side of the mass of intestines. The duodenum, to the point where it entered the neck of the volvulus, was notably distended. The site of obstruction was at the point where the duodenum was twisted round the pedicle.

From these facts, there can be little doubt that the case was a counterpart of *Case* 2—non-rotation, with secondary volvulus of the entire midgut loop and acute duodenal obstruction shortly after birth.

Clément[9] describes a similar case under the title "Volvulus de l'Intestin grêle, avec Sténose secondaire du Gros Intestin, chez un Nouveau-né".

The child was two weeks premature, but otherwise apparently normal. It passed meconium, and took its feeds; it did not vomit. On the second night it was found in its cradle looking very pale, and the temperature was 35° C. The abdomen became very distended and tense, and the subcutaneous veins of the abdominal wall became dilated. (There is no note as to vomiting at this time.) It died in collapse during the second day of illness.

Post-mortem examination showed that the small intestine was drawn together into a congested mass. The mass was supported by a narrow, twisted pedicle at the origin of the superior mesenteric artery. There were two complete spiral turns in a clockwise direction. The transverse colon crossed behind the mesenteric vessels, where it was compressed. (I think this point need not be stressed, as the bowel above was not distended.)

The author fails to recognize the significance of the retro-arterial position of the transverse colon, for he says that there was a volvulus, "but not a volvulus of the entire vitelline loop, for in spite of two spiral turns, the large intestine was in its place". His illustration of the specimen is the counterpart

of *Fig.* 180, and I think there is no doubt that the entire midgut loop was involved in the twist, and that the retro-arterial position of the colon represents its implication in the volvulus. It is not possible to determine from the facts given whether the condition, at birth, was one of non-rotation or reversed rotation. The case is of interest as representing acute intestinal strangulation as the outstanding feature, in contrast to the greater prominence of obstructive signs in the other cases of this class.

Rixford[10] describes a case of great interest, both from the embryological and symptomatic standpoints, and from the operative treatment, which he applied with complete success.

The patient was a boy of 5 years, who had suffered from chronic intestinal obstruction since the first few days of infancy. There were recurrent attacks of colicky pain and vomiting (presence or absence of bile in vomit is not mentioned). These attacks followed immediately after meals, and were very frequent; they were relieved by abstaining from food. He had never been able to take a normal full meal at any time. There was a severe degree of emaciation, due to partial starvation. The abdomen was distended in its upper part and concave below.

A chronic high intestinal obstruction was diagnosed and laparotomy undertaken. The obstruction was found to be due to an extensive chronic volvulus of the intestines. Included in the volvulus were the entire small intestine from below the biliary papilla, the ascending, and part of the transverse colon. Only the stomach, pylorus, and upper duodenum were distended; the remainder of the intestines were collapsed and atrophic. The site of obstruction was at the duodenum, just below the biliary papilla. The entire mass of intestines, having no other point of attachment than the twisted pedicle, which consisted of a cord hardly more than an inch in diameter, was lifted bodily out of the abdomen. The mass could then be twisted about freely in any direction. On untwisting the volvulus in an anti-clockwise direction through one complete turn, adhesions came into view, which bound the duodenum to the transverse colon. These bands were cut. The intestinal mass was then turned further in an anti-clockwise direction, so that the ascending colon lay to the right, the transverse colon in front of the origin of the superior mesenteric artery, the small intestine to the left, and the duodenum behind the origin of the artery. The viscera were replaced into the abdomen. The tissues assumed this normal position quite readily. The duodenal obstruction was completely relieved by this artificial construction of normal relations.

Improvement was immediate, and, in the author's words, "he grew like the blossom stalk of an aloe, and is now a strapping, normal boy of 13."

SOME SPECIAL POINTS IN THE SURGICAL PATHOLOGY OF VOLVULUS NEONATORUM DUE TO ANOMALIES OF INTESTINAL ROTATION.

From the point of view of surgical pathology, the salient features of the condition are distinctive and peculiar. A volvulus of intestine usually implies a more or less limited segment of bowel whose extremities are occluded by the compression of the twist, and whose blood-supply is seriously embarrassed or completely interrupted by compression of its mesentery. It is at once recognized as a greatly congested and dilated portion of intestine, sharply demarcated from the bowel above and below.

Here the conditions are so entirely different as to demand special consideration. The extent of intestine implicated in the volvulus is so unusually great as to render recognition of the condition difficult. There is obstruction only at the upper extremity (duodenum) of the twisted gut; the

lower extremity (ileum or transverse colon) suffers no occlusion; collapse, not dilatation, of the implicated bowel takes place. The degree of vascular obstruction varies, but tends to be slight. It was severe in one case (Clément), and quite absent in another (Rixford). In the remainder it was present, but of mild degree, causing but slight congestion of the intestines involved.

Above the site of duodenal obstruction, the usual phenomena consequent on intestinal occlusion from any cause are present. The upper duodenum and stomach become dilated; as their maximum capacity is reached their content is regurgitated. In the later stages their vitality is impaired by extreme dilatation, and inflammatory reaction with extravasation of blood occurs in their walls.

I would emphasize that one is essentially dealing with acute duodenal obstruction, due to external pressure on the gut. The obstruction is caused by a volvulus from which all the characteristic features of the condition are absent.

THE DIAGNOSIS OF ANOMALIES OF INTESTINAL ROTATION.

1. **Clinical Diagnosis in the Presence of a Lesion Independent of the Anomaly.**—Inflammatory lesion of an appendix, misplaced on account of anomalous rotation, is the chief consideration. It is necessary only to mention the well-recognized retrocolic and subhepatic locations of appendicitis. It is diagnosed when the circumstances and history are opposed to biliary or renal conditions, and favour appendicitis as the cause of local inflammation. It is a diagnosis of probability, and cannot be dogmatic. For example, I saw some time ago a case of leaking duodenal ulcer with localized abscess in a girl of 16 years, which was provisionally diagnosed as subhepatic appendicitis. The opinion was justifiable, but proved to be incorrect. These locations of the appendix are dependent on deficiency of the third stage of intestinal rotation.

In cases of obscure inflammatory lesions of the left side of the abdomen, appendicitis with non-rotation of the intestine is to be considered—more especially in the young. In older persons it is to be differentiated from left salpingitis, from sigmoid diverticulitis, and from inflammatory complications of neoplasm. If appendicitis is thought to be the most probable cause, subsequent operation may be facilitated by gaining knowledge as to the disposition of the large intestine. Non-rotation may be recognized by the elicitation of the distinctive colonic percussion note over the greater part of the left abdomen, and its absence from the right side (Mayo[25]). Complete transposition of the viscera is easily excluded by examination of the liver, etc.

Less easily differentiated are cases in which the 'wandering cæcum' has transgressed the middle line. The wandering cæcum (a defect of mesenterial fixation at the third stage of rotation) may lie in the left abdomen anywhere between the lower pole of the spleen and the left pelvis. In such cases a diagnosis of non-rotation would probably be made. I did so recently in a case of left pelvic appendicitis in a child. On opening the abdomen by a left iliac incision, the misplacement was found to be due to 'excessive rotation' of a mobile cæcum, which was so long that it reached the left side.

In cases where circumstances permit, and an acute inflammatory lesion does not contra-indicate it, the pre-operative diagnosis is greatly simplified and assured by X-ray examination with the bismuth enema.

The clinical diagnosis of non-rotation, while not of prime importance, will aid the planning of the operation and the precision of its conduct. If the left-sided location is associated with non-rotation, the root of the appendix will be found on the right side of the cæcum. If a mobile cæcum has become folded up under the spleen, or has crossed the pelvic floor to the left side, the root of the appendix will be found on its upper or left surface.

2. **Diagnosis at Operation.**—In exploratory operations of the intestines it is important that abnormal dispositions should be recognized and quickly followed at whatever point the abdomen may have been opened. In operations designed to apply to a particular portion of intestine, as in gastro-jejunostomy, their recognition may be of very great consequence. For example, in operating for gastric ulcer, Armstrong[11] found the condition of non-rotation. He performed gastrojejunostomy. No duodenojejunal flexure could be found, but a fixed portion of intestine resembling it proved to be the ileum. Armstrong's knowledge of the characteristic features of non-rotation saved his patient from having a gastro-ileostomy performed.

On opening the abdomen in the right iliac region the large intestine cannot be found,—This may be due either to failure in descent of the cæcum or non-rotation. The relations of the duodenum will at once decide the question. If the duodenum passes down the right side of the root of the mesentery and is not covered by the colon or mesocolon, the condition is that of non-rotation; the cæcum is to be sought in the left iliac or left pelvic sites. If the large intestine is found to cross the duodenum, the cæcum is to be sought in the subhepatic region or folded back towards the splenic flexure.

On opening the upper abdomen the transverse colon is not apparent,—This may be due to non-rotation or to reversed rotation. The position of the duodenum will decide the question. If the duodenum, uncovered by large bowel and possessed of a free mesentery, passes down the right side of the root of the mesentery, non-rotation is present, and the ascending colon will be found to pass up the left side of the vertebral column; there is no duodenojejunal flexure, and the upper coil of jejunum is in the right hypochondriac region. If the jejunum crosses in front of the mesenteric vessels, from right to left, the condition of reversed rotation should be suspected, and the transverse colon identified behind the origin of the superior mesenteric artery; the ascending colon is in its normal place; there is no duodenojejunal flexure, and the upper coil of jejunum will be found about the mid-line, in front of the mesenteric root.

On opening the abdomen in the left iliac region a portion of large bowel is found lying parallel to the descending colon,—Non-rotation should be suspected; the abnormal colon is probably the ascending colon, passing up from the left-sided cæcum on the left side of the vertebral column.

3. **Diagnosis in the Presence of a Lesion Consequent on the Anomaly.**—In chronic intestinal obstruction due to abnormal adhesions, kinks, etc.,

associated with anomalies of rotation, the abnormal disposition of the intestines will be discovered either by alteration in tympany, as noted above, or at the routine X-ray examination.

In adults with anomaly of rotation, acute intestinal obstruction is usually due to a volvulus of the ileocæcal segment. In these circumstances ~~I do not think~~ a diagnosis of the anomaly would be possible, or of practical importance. The treatment of the bowel would be governed by exactly the same considerations as for any form of volvulus. In the presence of anomaly of rotation, however, the conduct of operation would certainly be facilitated by familiarity with its characteristic disposition.

In infants with anomalies of rotation, extensive volvulus with acute duodenal obstruction is met with. In these cases, ~~I think~~ a correct diagnosis is more possible than in the lesions of later life, and it is of far greater importance. The child is apparently normal when born, and remains so for some days. Meconium is passed, and if the onset of the volvulus has allowed time, food residue appears in the motions in due course on the third or fourth day. With the onset of volvulus there may be shock, though this was remarked in one case only. Vomiting begins early. It occurs in relation to food, and represents expulsion of the contents of an over-full stomach, which has failed to empty itself via the duodenum. The vomit is soon deeply stained with bile, for the obstruction lies below the duodenal papilla. In the later stages there is hæmatemesis from gastric dilatation and erosion. Gastric peristalsis may be observed. The upper half of the abdomen becomes distended by the stomach and duodenum, while the lower half becomes recessed from collapse of the intestines and from general emaciation and loss of body fluid. The degree of constipation varies with the degree of obstruction. The undue persistence of traces of meconium is significant of the onset of a high intestinal obstruction at a period before food residue had reached the colon. Melæna may or may not be evident.

The differential diagnosis is to be made from hypertrophic pyloric stenosis, the various forms of congenital atresia or stenosis of the intestines, pressure of a mesenteric cyst; and from acquired causes, strangulation by a persistent Meckel's diverticulum or vitelline artery, volvulus of a limited portion of the ileum, and intussusception.

Pyloric stenosis is distinguished by the later onset of symptoms, by the absence of bile from the vomit, and by the shorter interval between feeding and vomiting. Atresia of the duodenum above the papilla is distinguished by very early vomiting—it may be of liquor amnii within an hour or two of birth—and by similarity in other respects to pyloric stenosis. Congenital obstruction in the lower part of the duodenum of course most closely resembles volvulus neonatorum of anomalous rotation. If there is complete atresia, the absence of meconium from the intestine below furnishes a differential point. If there is only a partial stenosis, meconium may be present, and its evacuation is delayed. In this case the time of onset of vomiting is the only basis for distinction. It occurs as soon as sufficient food has been taken to fill the stomach and upper duodenum in the case of congenital stenosis; but it commences after the onset of acquired volvulus. Congenital atresia and stenosis lower in the intestine are distinguished by the more marked and

generalized abdominal distention; by the dissociation between the times of feeding and vomiting; and by absence of, or delay in evacuation of, meconium. The congenital tumour which may cause intestinal obstruction in early infancy is the mesenteric cyst; its size, definite outline, and mobility should identify it.

The acquired lesions, other than anomalous rotation with volvulus, which may cause intestinal obstruction at this age, all affect the lower part of the small intestine or the colon. They are differentiated by their more acute onset and lack of relationship between vomiting and feeding.

Imperforate anus and strangulated external hernia need not be considered in this relation.

TREATMENT.

In the adult, the treatment of conditions dependent on anomalies of intestinal rotation, chronic obstruction from adhesions and kinks, and acute obstruction from volvulus, is guided by the same principles as apply to similar lesions from other causes. When intervention is necessary, the details of operative procedure are, of course, influenced by the anatomical conditions which are present.

In the new-born, the treatment of the extensive volvulus requires special consideration. Early operative interference holds out the only hope of saving life. One has to treat acute duodenal obstruction, the result of external pressure on the gut. The pressure can be relieved by reduction of the volvulus and the construction of normal conditions. Rixford has successfully done this in the exceptional case of a child who survived with partial obstruction to the age of 5 years. From the examination of the two specimens from new-born infants which I describe above, I suggest that reduction of the volvulus would be the most hopeful treatment at this age also. The intestinal mass would have to be delivered, and untwisted. One would have to decide at operation whether the duodenum were more efficiently freed of pressure or kink by leaving the reduced volvulus in the condition of non-rotation, or by carrying the mass further round to the normal position. In the two specimens examined, reduction to normal appeared to give the better result. Some form of fixation to prevent recurrence would be desirable, and I suggest that the cæcum and ascending colon could be anchored in the right loin by a few points of suture to the parietal peritoneum in that region.

If on account of adhesions reduction were not feasible, gastro-jejunostomy might be successful, for the blood-supply of the intestine is not threatened, nor is the returning segment of the volvulus obstructed. This operation involves the regurgitation of the biliary and pancreatic secretions via the stomach, and is, moreover, a more drastic procedure than reduction and fixation of the volvulus would be. It may be noted that only two records of successful operation by short-circuit for obstruction to the small intestine at this age are to be found. Ernst[49] operated at the eleventh day of life for atresia of the duodenum; he performed 'duodeno-entero-anterior anastomosis' with good result. Fockens[50] operated at the eighth day of life for atresia of the ileum; he performed entero-anastomosis with success.

SUMMARY.

1. The three stages of normal embryonic intestinal rotation are described. In the second stage the essential disposition of the intestines is attained.

2. Derangements of intestinal rotation are described and arranged under three heads: (i) The first stage of rotation; (ii) The second stage (subdivided into three groups, (*a*) non-rotation, (*b*) reversed rotation, (*c*) mal-rotation); (iii) The third stage.

3. It is suggested that the cause of anomalies of the second stage is variation in size of the embryonic umbilical orifice.

4. The pathological consequences of anomalies of the second stage of intestinal rotation are described, and their incidence and relative frequency are estimated from the literature. Failure of sufficient intestinal fixation and consequent volvulus is found to be the typical lesion. Volvulus from this cause has its highest incidence in the first few days of life, and at this time a very extensive volvulus is characteristic. Volvulus of the ileocæcal segment is the typical lesion in later life.

5. Three cases of volvulus due to anomalies of intestinal rotation are reported: (i) Reversed rotation and volvulus of the ileocæcal segment in an old man; (ii) Non-rotation and volvulus of the entire midgut segment in a new-born child; (iii) Mal-rotation and volvulus of the entire small intestine in a new-born child.

6. Three similar cases from the literature are briefly quoted.

7. Some special points in the surgical pathology of extensive volvulus in infants are considered.

8. The diagnosis of anomalies of intestinal rotation is considered: (i) from the standpoint of abnormally situated appendicitis, (ii) from the point of view of recognition on the operating table, (iii) in cases of secondary volvulus, especially in the new-born.

9. An operative treatment by reduction and fixation is suggested for cases of extensive volvulus in the new-born, based upon an examination of two specimens of the condition.

APPENDIX.

EXOMPHALOS AND NON-ROTATION.

Since writing the above paper two cases of exomphalos have come to my notice, and the condition of the midgut loop in them is of great interest in connection with intestinal rotation, both from the embryological and surgical aspects. I am indebted to Mr. John Fraser for permission to publish these cases.

Case 4.—**Complete exomphalos and bilateral equinovarus: death.**

Baby B., male, age 36 hours, was admitted on June 13, 1923, to the Royal Hospital for Sick Children, Edinburgh, under Mr. John Fraser's care. The child suffered from the complete exomphalos shown in *Figs.* 182 and 183 and a bilateral

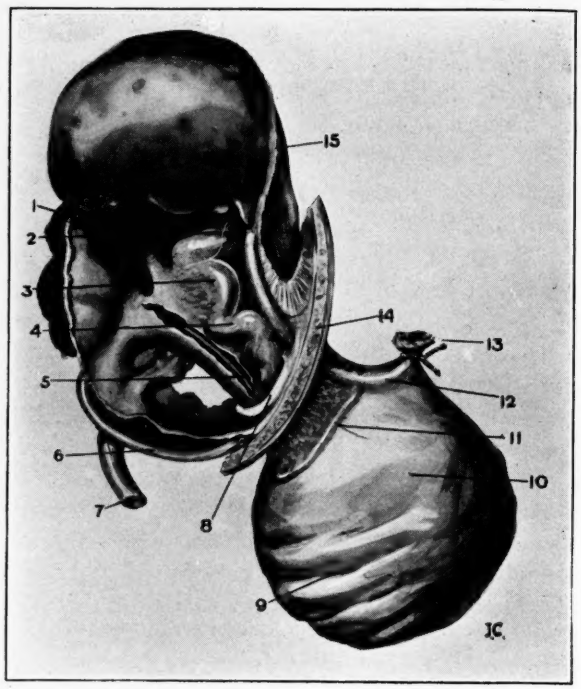

FIG. 182.—Exomphalos. Specimen from *Case* 4. Right lateral view. Note especially the relation of the duodenum to the superior mesenteric artery. The pylorus crosses the vessel anteriorly, and the duodenum descends from it on the right side of the artery to enter the neck of the sac in this relationship. The short mesoduodenum, part of which contains the head of the pancreas, is characteristic of non-rotation. The manner in which the mesenteric axis is stretched out between the posterior abdominal wall and umbilical orifice is striking. The area of true skin at the neck of the sac is well seen; beyond it is the sac formed of distended umbilical cord, and through its thin wall the intestinal convolutions are clearly visible. The umbilical vein is seen to pass over the cephalic surface of the sac wall to reach the stump of the cord.

1, Right kidney. 2, Pylorus. 3, Pancreas. 4, Duodenum. 5, Superior mesenteric artery. 6, Hypogastric artery. 7, Rectum. 8, Umbilical orifice. 9, Small intestine. 10, The sac. 11, Margin ot true skin. 12, Umbilical vein. 13, Stump of cord. 14, Abdominal wall. 15, Falciform ligament.

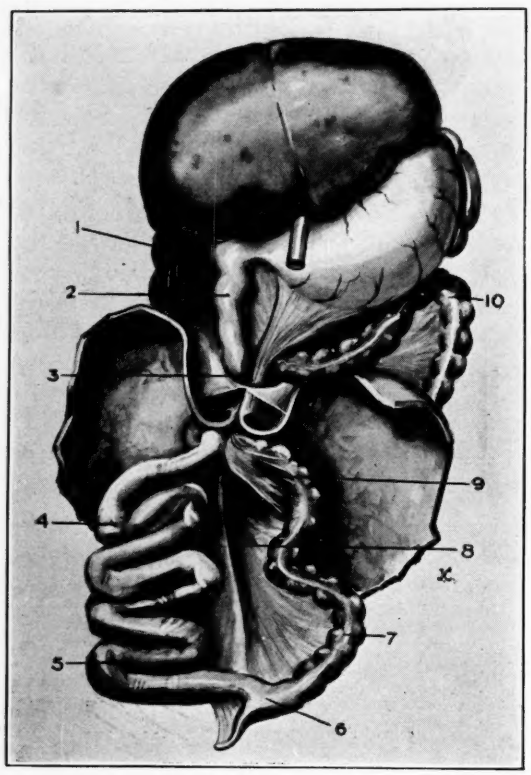

FIG. 183.—The same as *Fig.* 182. Anteroposterior view, with the sac opened. The sac has been laid open in such a way as to leave only the umbilical orifice intact. The duodenum is seen to descend on the right side of the middle line, and to pass into the jejunum in the right side of the sac. There is no duodenojejunal angle. The small intestine lies entirely in the right half of the sac in a convoluted mass. The splenic flexure and adjacent transverse part of colon are normal. The colon enters the sac by passing through the left side of the umbilical orifice and occupies the left part of the sac. The lower end of the ileum and cæcum are seen to form the apex of the midgut loop in the sac, and the mesenteric vessels are seen coursing down to this point. Note that the great omentum has become attached to the transverse colon in spite of its extra-abdominal position.

1, Right kidney. 2, Duodenum. 3, Umbilical orifice. 4, Jejunum. 5, Ileum. 6, Cæcum. 7, Ascending colon. 8, Superior mesenteric vessels. 9, Great omentum. 10, Splenic flexure.

talipes equinovarus. He was slightly premature, but otherwise normal. The sac wall was obviously infected, and already the sac contained a quantity of exudate, the consequence of a commencing peritonitis. He was already so seriously toxæmic, and the protrusion was so large, that operation with a view to reduction was contra-indicated. The child succumbed to toxæmia within sixteen hours of admission.

At the post-mortem the specimen shown in the figures was removed.

Case 5.—**Partial exomphalos, without associated deformities: operation, recovery.**

Baby W., male, age 12 hours, was admitted on June 19, 1923, to the Royal Hospital for Sick Children, Edinburgh, under the care of Mr. John Fraser. The child suffered from a partial exomphalos. There were no associated deformities, and he was in good condition. The sac, about the size of a small orange, consisted of the distended root of the umbilical cord, and the umbilical vein and arteries were obvious, coursing over its cephalic surface (*Figs.* 184 and 185). The sac wall was already obviously infected. Immediate operation was undertaken by Mr. Fraser.

The neck of the protrusion was surrounded by an elliptical incision and the sac opened near this point. It contained a small quantity of inflammatory exudate with flakes of lymph and intestinal coils, deeply injected on account of a commencing peritonitis. There were dense adhesions about the neck of the sac. These were separated, and the sac was completely removed. The raw areas of adhesion of the bowel were re-peritonized. It was noted that the extruded intestine consisted of the cæcum, appendix, and lower ileal coils. These parts were in the position of non-rotation, the cæcum lying on the left side of the sac in the reversed position, the ileum occupying the right part of the sac. Reduction through the narrow umbilical orifice was not possible, and it was necessary to enlarge it by incising the linea alba above and below it. It was then found that the remainder of the small intestine occupied its normal site within the abdomen, but the proximal half of the colon was anchored over to the umbilicus and therefore was absent from its normal position. Without difficulty, rotation of the midgut loop was artificially completed, and the viscera were placed within the abdomen in their normal sites. The abdomen was closed.

The child made an uneventful recovery and left hospital thirteen days later in perfect health.

Exomphalos is the condition in which the embryonic and physiological hernia into the root of the umbilical cord has wholly or partially persisted until birth. It is clearly distinguished from true umbilical hernia by its external appearances. In contrast to the true skin which covers the former, the sac of exomphalos is, indeed, the root of the cord, much stretched out, and is recognized as a thin, translucent, gelatinous-looking membrane. The neck of the sac is surrounded by true skin, and the line of demarcation between skin and cord is clearly defined (*Fig.* 182). The vessels of the cord course irregularly over the cephalic surface of the stretched sac, to meet together at its apex to form the cord. The sac contains the midgut loop, in whole or part. The loop is in the non-rotated condition, and the cæcum and lower end of the ileum lie at its apex. Thus, in a complete exomphalos, the infant is in exactly the same condition as an embryo of the ninth week, so far as its umbilical sac is concerned. We have already expressed the view (originated by Frazer and Robbins) that the second and essential stage of rotation of the midgut loop is dependent on the reduction of the embryonic hernia, and further, on the sequence in which the contents are reduced. Here, in the condition of exomphalos, we have proof of this hypothesis, for as

reduction has not occurred, the intestine remains within the sac in the primitive, non-rotated condition. A further point of interest in relation to the mechanism and sequence of reduction is the fact that the cæcum and lower ileum form the apex of the extruded loop, occupying the middle line, at the most dependent part of the sac. The ascending colon and major portion of the transverse colon form the left limb of the loop. The convoluted small intestine forms the right limb. The two limbs pass through the umbilical orifice close together, and this point of approximation is the original embryonic duodenocolic isthmus. In partial exomphalos the cæcum and lower coils of the ileum are usually present in the sac, although the greater part of the small intestine and of the colon have been returned to the abdomen. In such a case non-rotation affects that portion of the intestine which lies within the sac, and the cæcum is found to be reversed—i.e., the ileum enters its right side—while the remainder has taken up a normal position. Occasionally the lowest coil of the ileum occupies the sac. These facts strongly support the view that the cæcum and lower ileum are normally the last portion of the midgut loop to undergo reduction, and we may consider the condition of partial exomphalos as representing an arrest of the normal process of reduction.

FIG. 184.—Partial exomphalos. *Case* 5. Lateral view of sac. Note the sharp line of demarcation between the true skin at the neck of the sac and the distended umbilical cord which forms its walls. On the summit of the protrusion is the ligatured umbilical cord.

FIG. 185.—The same as *Fig.* 184. Anterior view. Note the ligatured umbilical cord projecting from the summit of the sac. The umbilical vessels are well seen coursing over the cephalic surface of the sac and converging on the cord. The two arteries occupy either side of the median plane, while the vein lies further to the left.

The recognition of these facts is of surgical importance, for in operating to repair the defect a knowledge of the disposition of the parts is essential.

The intestines are invariably adherent at the neck from long-standing constriction at this point, and frequently there are extensive adhesions to its walls, for the delicate sac becomes the site of a localized 'peritonitis' from the time of birth. Under such conditions the distinction of parts is by no means easy.

It is also of importance that, by means of this knowledge, the viscera

can be disentangled and placed in their normal sites within the abdomen. In *Case 5*, Mr. Fraser accomplished this with complete success, freeing and rotating the extruded portion of the midgut loop and placing the cæcum in the right iliac fossa.

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A CASE OF SECONDARY HYPERNEPHROMA IN THE FEMUR WITH SPONTANEOUS FRACTURE.

By L. R. BROSTER, London.

Mrs. E. T., age 72, was admitted to the Charing Cross Hospital under Mr. H. S. Clogg in February, 1923.

History.—The patient stated that in June, 1914, she had been operated upon by Sir John Thomson-Walker at the Hampstead General Hospital and that her right kidney had been removed. Up to July, 1922, she had been perfectly well, but while walking in her home her leg gave way; she then fell and was unable to get up. She felt no pain at the time. She was seen by her doctor, who diagnosed fracture of the right femur, and admitted her into the local Cottage Hospital, where the limb was splinted. She was allowed up in a chair in November, and while being wheeled about she slipped off the

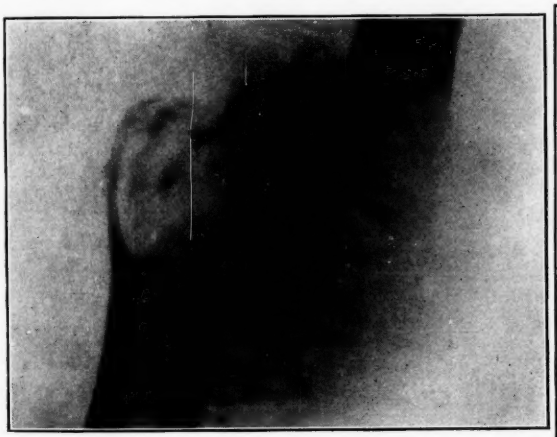

Fig. 186.—Lateral view of fracture.

Fig. 187.—Anteroposterior view.

chair and injured her right femur again. The limb was re-splinted, and soon after a swelling appeared in the upper third of the thigh.

Clinical Examination.—There was a large tumour about the size of a cocoanut in the upper third of the right femur. The swelling was more noticeable on the anterior aspect of the thigh. It was tender, tense but elastic, with indefinite edges. There was no sign of inflammation. It was attached to bone, but not to skin or muscle. A distinct impulse could be detected in the tumour, synchronizing with the heart-beat, and on auscultation a bruit was audible all over it. The distal pulse was unaffected. Further clinical examination proved fruitless.

RADIOLOGIST'S REPORT (*Figs.* 186 and 187).—"General decalcification of femur. Pathological fracture of the shaft. Considerable destruction as a result of malignant growth. Difficult to say what the type of growth is, as the fracture has confused the picture. Most likely a secondary carcinomatous deposit or an endosteal sarcoma."

OPERATION. — A diagnosis of secondary hypernephroma was made, and disarticulation at the hip-joint was performed by Mr. H. S. Clogg, followed by an excellent recovery.

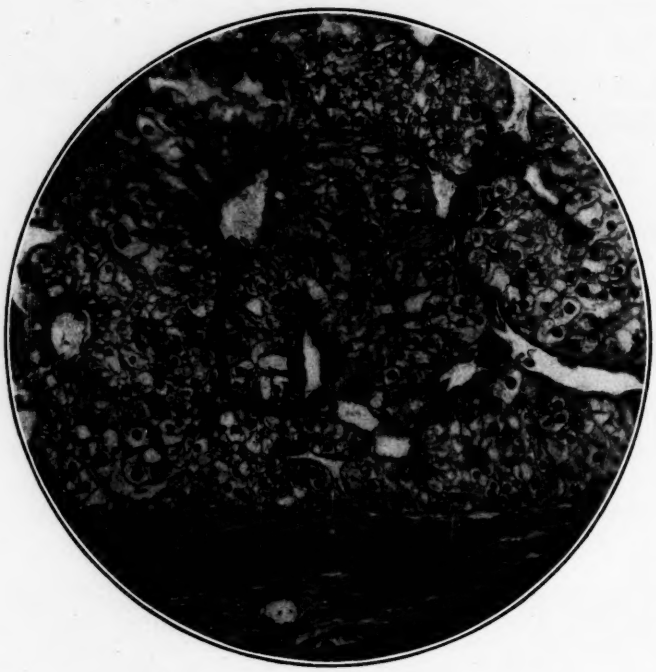

FIG. 188.—Section of the tumour.

By kind permission of Sir John Thomson-Walker the following report was subsequently received from the Hampstead General Hospital.

"Mrs. E. T., age 61, admitted on June 25, 1914, complaining of hæmaturia and painful micturition.

Previous History.—Recent acute attack of abdominal pain and hæmaturia, and a small amount of hæmaturia two years previously.

Examination. — Right kidney movable, reaching down to the anterior superior spine.

Cystoscopy. — Right ureter normal in position, large open rigid orifice with sharp edges. It contracted but did not close fully. Left ureter normal.

July 31, 1914.—Right kidney removed. Large hypernephroma at the upper pole.

Aug. 29.—Discharged fit."

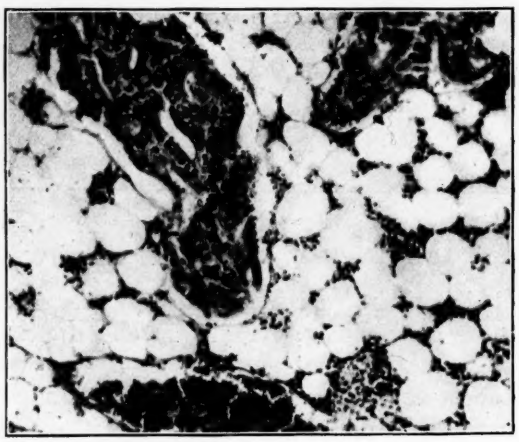

FIG. 189.—Showing hypernephroma cells within the lumen of blood-vessels.

FUNCTIONAL ACTIVITY OF REMAINING KIDNEY.—*Urea* in 24-hours' specimen: 1·5 per cent.

Urea concentration test: First specimen, 1 per cent; second specimen, 2·4 per cent; average, 1·7 per cent. This is below normal.

Blood urea, 14 mgrm. per 100 c.c. of blood. This does not indicate any retention.

Subsequent X-ray examination for other bone metastases proved negative, except that there was " collapse of fifth lumbar vertebra. Hardly any of the centrum remains. Lateral displacement of the fourth and fifth lumbar vertebræ." This can hardly be regarded as another secondary growth in the spine; but it is suggestive, and further clinical evidence is not yet forthcoming.

Microscopy of the Tumour.—A section from the growth (*Fig.* 188), shows the typical appearance of a hypernephroma, and it bears out in a striking manner the statement of the true mimicry which secondary hypernephromata exhibit for their parent tumour.

Fig. 189 shows a section taken from another part of the tumour in which hypernephroma cells are seen within the lumen of the blood-vessels. This will be referred to subsequently in discussing the dissemination of hypernephroma, and it may be added here that prolonged search for any tumour cells in the substance of the periosteum, both proximal and distal to the tumour, proved negative.

Naked-eye Appearances.—*Fig.* 190 is a drawing of the femur, which has been split longitudinally on opposite sides above and below the tumour. *Fig.* 190*a* shows the spread of the growth down the medulla in the upper half of the bone, whereas *Fig.* 190*b* shows the line of cleavage of the fracture with normal medulla below. This is a good illustration of the point raised by Piney,[1] who maintains that secondary malignant tumours in bone are blood-borne, and begin in the red marrow of the proximal long bones, which comprises a small area at the upper end of the diaphysis. The red marrow consists of innumerable blood channels with thin walls. Consequently there must be considerable widening of the blood-stream, with a corresponding decrease in

a *b*

Fig. 190.—*a*, Showing the growth and the involvement of the medulla above it. *b*, Showing line of cleavage of the fracture and no extension of growth down the medulla of lower end of femur.

the rate of the blood-flow, factors favouring the lodgement and growth of malignant cells in circulation. As soon as the deposit starts growing it spreads down the medulla, and spontaneous fracture takes place lower down, where the compact bone is thinner. The same author adds that he can detect no lymphatics in bone-marrow.

Piney[1] has drawn attention to very definite changes which occur in the blood picture, and the case under review, although not quite typical, is sufficiently characteristic for the diagnosis of metastasis in bone-marrow to be made.

In the present case the following blood-count was made subsequent to the disarticulation of the limb, so that the degree of anæmia is probably pronounced :—

Reds	4,280,000
Hæmoglobin	70 per cent
Colour index	0·8
Whites	13,000 per c.mm.
Polymorphonuclear	82·5 per cent
Small lymphocytes	9·0 „ „
Large lymphocytes	0·5 „ „
Myeloblasts	1·5 „ „
Eosinphils	0·5 „ „
Large hyalines	5·5 „ „
Myelocytes	0·5 „ „

No nucleated reds seen while counting 400 whites.

Summary of the diagnostic changes exhibited in this count :—

1. A slight leucocytosis, characterized by the presence of myeloblasts and myelocytes.

2. A slight reduction in the number of reds, with a relatively high colour index.

This differs from a post-operative anæmia, where there is a low colour index, increased white count, and an absence of myeloblasts and myelocytes ; and also from a pernicious anæmia or the septic anæmia described by Hunter, which are characterized by :—

1. Reduction in the number of red corpuscles, with a colour index above 1.
2. Slight leucopenia, with relative lymphocytosis.
3. Myeloblasts and myelocytes rare.
4. Nucleated red corpuscles always present.

Keyser and Foulds,[2] in an article on " The Extension of Hypernephroma by the way of the Renal Vein ", investigated a case with the following history. A man complaining of hæmaturia had his right kidney removed for hypernephroma. Two months later he developed a pulsating swelling in his tibia, and died seven months afterwards.

Many sections of this kidney were cut, with the following results. Blocks of the renal artery, pelvis, and ureter showed no abnormality. Those of the main renal vein showed extension of the growth by this route. Its lumen was filled with hypernephroma cells, and the walls showed leucocytic but no tumour infiltration, and there was no tendency of the tumour to perforate the wall of the vessel. The smaller radicals of the renal vein showed destruction of their endothelial lining, but again there was no mural invasion

by growth, although the walls were thinned by pressure. In the lumen of the venules in the renal tissue growth was detected with no invasion of the walls, although it was difficult to say whether these were veins or lymphatics. The authors conclude that they were the former.

This raises the question of the evidence upon which the statement is based that hypernephromata are disseminated by lymphatics. The literature quotes many cases of metastases in the regional lymph glands and in glands unconnected with the primary growth, but is unusually silent on the question of the transference by means of the lymphatic system of the bone metastases, which form its preponderating manifestation. A close study of the lymphatic system of the kidney points to a few details which may be easily overlooked.

The lymphatic vessels form three plexuses : a deep set in the substance of the kidney, a superficial set under the capsule, which communicate freely with the third set in the perinephric fat. Four or five trunks issue from the deep set, and in the region of the hilum are joined by the superficial set, to follow the course of the renal vein and end in the lateral aortic lymph glands. The perinephric plexus drains direct into the upper lateral aortic lymph glands. A few inconstant glands are sometimes found in the hilum.

Now Keyser and Foulds state that there was no evidence of lymphatic extension, but that this investigation was unsatisfactory because the aortic glands had not been removed in the operation for nephrectomy. The same condition would obtain at an autopsy unless special care was taken to remove these tissues in a block dissection.

Carceau[3] states that occasionally the lymphatics spread this disease and in these cases the glands are enlarged. The regional glands are chiefly implicated, and rarely those of the inguinal region. Morris quotes a case where the glands involved were of much greater size than the primary growth in the kidney. It is also said that secondary deposits may give rise to metastases in the glands draining the region in which they are situated.

Cases.—To emphasize the difficulties in the diagnosis and the vagaries of the secondary manifestations in which the primary growth lies dormant, the following quotations from the literature are given :—

Paul Albrecht[4] records four such cases. The first is that of a man, age 60. His first sign was a spontaneous fracture through the lower third of the left femur. For this amputation was performed through the upper third. The condition was diagnosed as a myeloid sarcoma. Five years later a tumour appeared in the lower third of the right femur, another in the jaw, a third the size of a hazel nut over the third rib, and a fourth as a pulsating swelling in the skull. A year later his remaining femur fractured spontaneously, and a similar fate befell his left humerus in its upper third. At the autopsy a hypernephroma was found in his left kidney, with additional metastases in the bladder, lung, omentum, pancreas, and heart.

The second, a man age 42, developed a lump over the right frontal and parietal bones, which was diagnosed as an osteosarcoma. He died during the operation, and the tumour was found to be a hypernephroma.

The third was a man, age 48, who had a fluctuating swelling of the knee, which was thought to be tuberculous. Amputation was performed and the condition was found to be a hypernephroma of the lower end of the femur. The urine remained normal, and the patient later developed a tumour of the right kidney, and metastases in the right side of the head and in the metacarpal bone of the right middle finger.

The fourth was a woman, age 66. She complained of a lump over the clavicle, which was diagnosed as a cold abscess. At the post-mortem there was a hypernephroma in the left kidney, and in addition metastases in the left humerus, another below the right kidney, and a small one in the left lung.

Macleod and Jacobs[5] record two cases of secondary hypernephroma in the sternum which were diagnosed as aneurysm. Muscholl[6] records the sucessful removal of a hypernephroma in a woman of 30, which grew from the posterior abdominal wall, between the spine and the left kidney. It was adherent to the pancreas and had no connection with the kidneys or suprarenals.

Baumgarten[7] describes a case of 'malignant neoplasm' which remained the same size for twenty years with no disability. Its origin was in an accessory suprarenal between the layers of the transverse mesocolon, which derived its blood-supply from an anomalous vessel. It was successfully removed and the patient remained well for a time, and then developed pain in the left upper arm and the eighth right rib; later pain in the left femur and a swelling of the humerus. Before death she coughed up 'bloody sputum'. Unfortunately no result of the autopsy was added.

Bullowa[15] records the case of a man, age 61. He complained of pain in the right groin and right side radiating to the back. Two weeks later he developed a swelling in the right groin. He was operated upon for right hernia. Later he developed a lump over the twelfth dorsal vertebra which pulsated and emitted a bruit. Paraplegia followed and then death. At the post-mortem a hypernephroma the size of a tennis ball was found in the upper half of the left kidney; it was encapsuled and there was no extension into the veins. The lump in the right groin proved to be metastases in the glands.

Prognosis.—The prognosis of hypernephroma makes gloomy reading. On the whole the statistics given are fairly uniform, and raise interesting points of relative value.

Keen, Pfahler, and Ellis[8] give the duration of the disease as from fifteen weeks to eight years, with an average of two and a quarter years. Richards's[9] average works out at two and a half years, and Carceau's[10] at three and a half years. The expectation of life is very much shortened on the appearance of metastatic deposits, although Albrecht[11] describes a case which was alive and well two years and seven months after the removal of metastases in the scapula, the kidney having been removed four years previously. The same author describes a series of 16 nephrectomies, of which only 4 were alive after four years; of the latter, metastases appeared in 3. In another series of 24 operations, only 1 was alive four years after the operation.

Carceau[10] gives a comparative list of 143 nephrectomies. Of these the immediate mortality was 33; 43 died later after operation; 31 survived; and in 36 cases the results were not stated. Of the 43 who died later after operation, 22 died within the first year, the cause of death being metastases elsewhere.

The following table shows the length of time which elapsed between nephrectomy and death from metastases in 33 cases.

Period	No. of Cases	Period	No. of Cases
1 year and under,	17	4 to 5 years,	1
1 to 2 years,	8	7 „ 8 „	1
2 „ 3 „	4	10 „ 11 „	1 = 33.
3 „ 4 „	1		

The duration of life in the 43 cases who died later after nephrectomy was as follows:—

Period	No. of Cases	Period	No. of Cases
1 year and under,	22	4 to 5 years,	1
1 to 2 years,	11	7 „ 8 „	1
2 „ 3 „	6	10 „ 11 „	1 = 43.
3 „ 4 „	1		

The fate of the 31 survivors after operation is shown in the following:—

Period	No. of Cases	Period	No. of Cases
1 year and under,	9	4 to 5 years,	3
1 to 2 years,	6	5 „ 6 „	2
2 „ 3 „	7	6 „ 7 „	1
3 „ 4 „	2	9 „ 10 „	1 = 31.

Site of Metastases.—In Carceau's list the main metastases are given as follows: Bone 35, lungs 21, liver 8, regional lymph glands 11.

In the bone cases the relative frequency was: Femur 7, vertebræ 7, ribs 6, skull 5, clavicle 2, pelvis 2, humerus 2, scapula 1, jaw 1, tibia 1, metacarpus 1.

All parts of the body may be involved, although there is occasional immunity. Albrecht[13] gives 15 cases, in which bone metastases appeared in 8, and lung metastases in 7. He also says no spread along the urinary tract has been detected. H. L. Kretschner[14] describes hypernephromatous nodules in the skin.

Blood Changes.—With regard to blood changes accompanying secondary deposits in bone, the literature only contains two fleeting references. Keyser and Foulds[2] give the following blood-count in their case quoted above: Erythrocytes, 3,450,000; leucocytes, 10,000; hæmoglobin, 54 per cent. Here there is definite anæmia, which may be accounted for by the hæmorrhage.

Bullowa[15], in a case of hypernephroma with spinal metastases, gives the following differential white count: Leucocytes, 9200; polymorphonuclears, 72 per cent; transitionals, 2 per cent; lymphocytes, 25 per cent.

SUMMARY OF THE CASE.

1. The interesting point of this case is the length of time—nearly ten years—before the appearance of a bony metastasis after the removal of the kidney, the longest time quoted in the literature being ten years.

2. The site of fracture is the usual one, and the position of the secondary growth is in its usual position.

3. The conclusion is formed that the dissemination of secondary hypernephroma in bone takes place via the blood-stream, and the evidence is based on the detection of tumour cells within the lumen of the blood-vessels, and also on the absence of any infiltration of the lymphatic channels, especially those in the periosteum above the tumour.

I have pleasure in acknowledging my indebtedness to Mr. H. S. Clogg for allowing me to publish this case; also to Dr. Alfred Piney for his help and for photographing the sections.

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PAGET'S DISEASE OF THE NIPPLE.

By Sir GEORGE LENTHAL CHEATLE, London.

INTRODUCTION.

I propose to attack the problems involved in this article and arrive at definite conclusions concerning them by means of reproductions of whole sections of eight breasts suffering from Paget's disease of the nipple. The sections have been cut in paraffin by a microtome I had specially constructed, and they can be examined by a one-twelfth oil-immersion lens. There is no likelihood of being able to demonstrate and solve the problems connected with Paget's disease of the nipple without the aid of such sections of the breast cut in series. Further evidence is also included that has been gained from the examination of small sections from other breasts similarly affected.

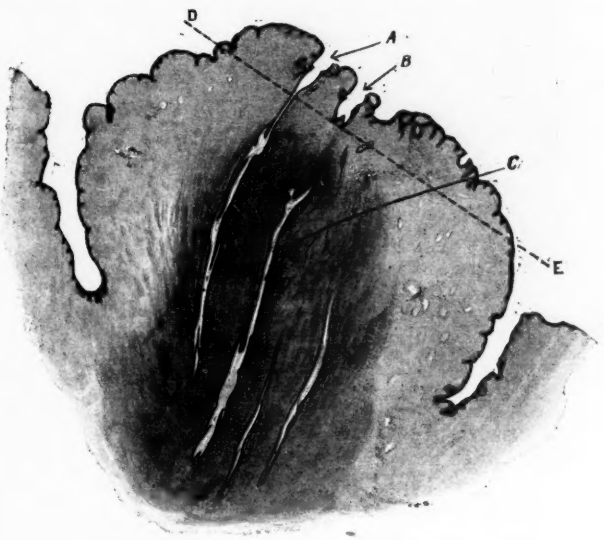


Fig. 191.—Drawing of a normal nipple. At A is a duct outlet. Into this the duct can be seen opening. B is a duct outlet containing the openings of two ducts. C is one of the ducts which open into this outlet. DE is the imaginary line which I have described in the text as being drawn parallel to the surface of the nipple below the duct outlets. It must be very rare for any carcinoma of the breast arising below this line to induce Paget's disease of the nipple.

I shall first refer to certain anatomical points that are important; then, after showing where Paget's disease of the nipple begins, proceed to describe the appearances of the disease in its different stages, and finally to place in correct relation to it the glandular carcinoma that is usually associated with it. In doing so I endeavour to adduce cogent reasons for considering that Paget's disease of the nipple is a primary malignant disease; also that the glandular carcinoma of the breast to which I have just referred is a secondary process, although it is a primary carcinoma arising in the epithelial cells of the gland. Further, I wish to enunciate what almost amounts to a law: That carcinoma arising in the breast below a line drawn parallel with the top of the nipple and immediately below the expansions of the outlets of mammary ducts (*Fig.* 191) does not induce Paget's disease.

FIG. 192.— High-power photograph of a duct outlet which contains a plug; otherwise it is normal. A is a sebaceous gland, the duct of which can be seen opening directly into the outlet. A_1 is another sebaceous gland. The arrow at B points to the surface of the nipple. The arrow at C points to the opening of a duct and shows its epithelium becoming a thin layer and passing from the squamous towards a columnar type.

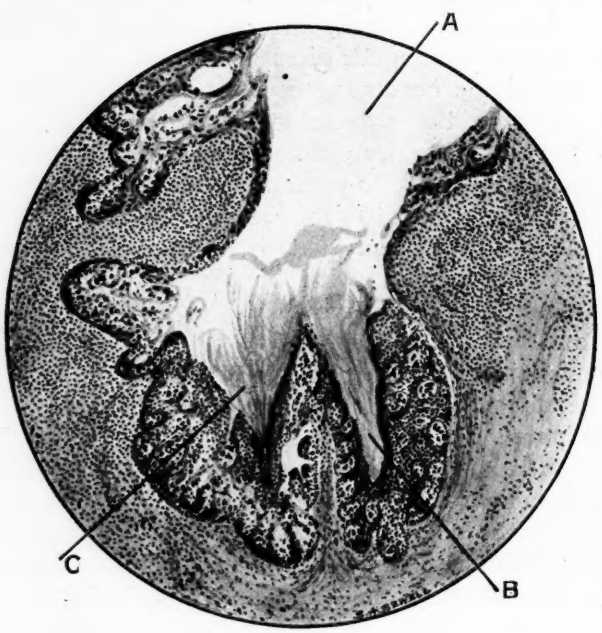


FIG. 193.—A plugged duct outlet, A, affected by Paget's disease of the nipple. Opening into the outlet are two ducts, B and C, into which the plug extends. B is the end of the duct D in *Fig.* 205, and C is the outlet of the duct A in *Fig.* 194.

Anatomical Points.—A mammary duct widens as it opens on to the surface on the top of the nipple. Into this outlet open the ducts of sebaceous glands which surround it (*Fig.* 192). The outlets of the mammary and sebaceous ducts are lined by the same type of epithelium as that which covers the nipple and its areola. Two ducts may terminate in one outlet (*Figs.* 191 and 193). The outlets of mammary ducts frequently contain plugs (consisting of desiccated shed epithelium and possibly sebum), which may extend a little way into the ducts (*Fig.* 193). The epithelial lining of a duct before reaching its outlet is in a transitional state, and is not columnar in type. The plugs may act as irritants, or their presence may encourage the action of other agents of irritation. A duct, whether its outlet be plugged or not, could under certain conditions act as a pathway to the deeper parts of a breast for agents of irritation (*Figs.* 191 and 194).

To show the possibility of cutaneous ducts acting as pathways for living agents of irritation, it is interesting to point out a cutaneous gland in which lies a nematode worm which gained entrance by means of a duct (*Fig.* 195). In other cutaneous glands worms of the same nature existed in different stages of evolution. The observation is new, and was discovered accidentally by my assistant, Mr. S. J. Mitchell, while preparing specimens for me of the normal skin of the frog.

It is also interesting and instructive to remind the reader that the basal epithelial cells lining the structures above the line referred to are pigmented, especially in women who have been pregnant.

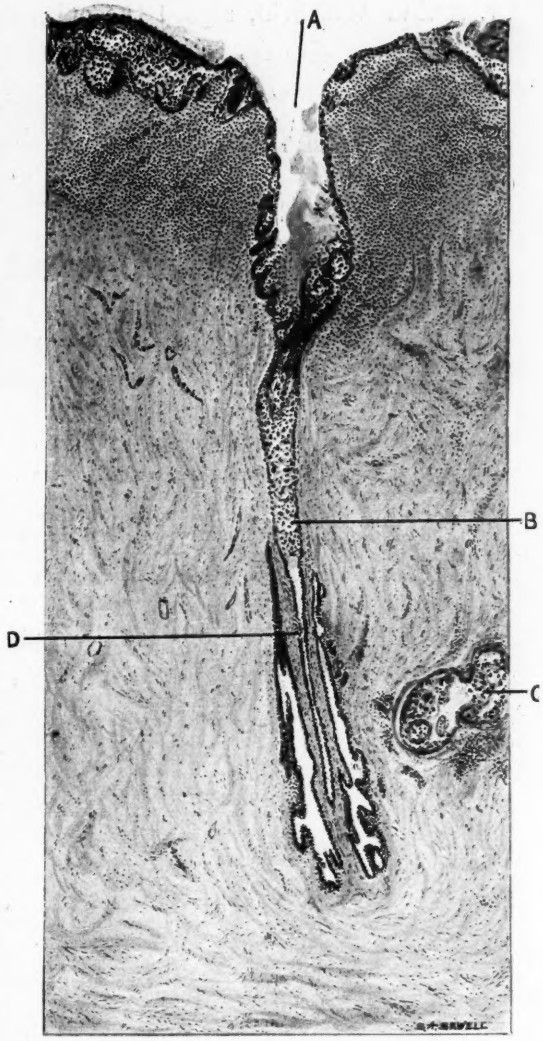


FIG. 194.—Shows a plugged duct outlet at A affected with Paget's disease of the nipple; into the outlet is leading a duct, the upper part of which is filled with carcinoma cells, B, which can be seen ending abruptly. The carcinoma somewhat resembles Paget's disease of the nipple. The cells have proliferated, were vacuolated, and had multiplied to the extent of filling and dilating the duct. There were no concentric bodies in these cells. The normal epithelium lining a duct at this part is undergoing a gradual change from the squamous to columnar type. At D, a collection of cells is seen resembling those in the tumour at B. A normal duct at this part is lined by columnar cells. As these cells at D are not columnar, it is possible that they have been transplanted from B. C is the columnar-cell carcinoma in the duct D in *Fig.* 205. The duct outlet, A, is part of the outlet C in *Fig.* 193.

The importance of this lies in the fact that Paget's disease of the nipple begins in the deeper layer of epithelial cells; and certain observers, notably Dr. Arthur Whitfield, regard the epithelial changes in that disease as similar

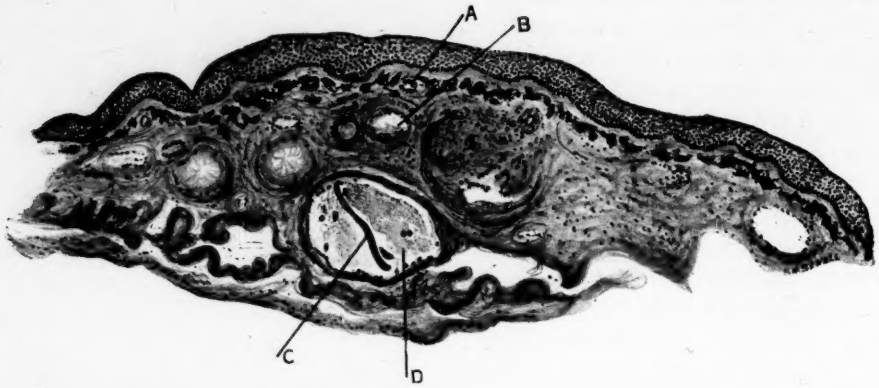


FIG. 195.—Section of a frog's skin. At D is a cystic cutaneous gland in which there is a nematode worm, C, which gained entrance by means of the duct A, B. The specimen appears to be unique, for no authorities whom I have consulted appear to be aware either of the condition or of the nature of the nematode worm. The parasite existed in a few more glands in various stages of its evolution. The condition seen in this section shows that ducts can be dangerous pathways for agents of disease.

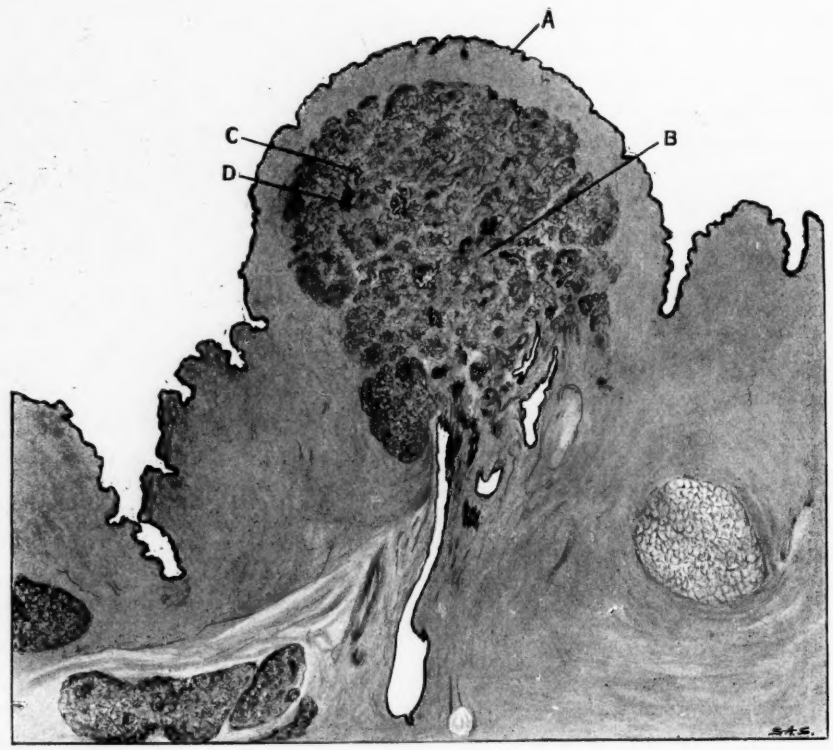


FIG. 196.—Section of the nipple, A, from breast of lactating female, age 36. The nipple is filled with secreting acini, B, which extend up to the normal epithelial surface; the stellate-form structures of which C and D are examples are ducts cut transversely. The main bulk of the nipple consists of acini.

to changes in a mole that has become malignant. In addition, the early changes in Paget's disease are remarkably like those seen in the earliest stages of rodent ulcer, which also arise in the deeper layers of epithelial cells. I would like the reader to compare *Fig.* 213 with the figures I published in a paper on "The Multicentric Origin of a Rodent Ulcer" (THE BRITISH JOURNAL OF SURGERY, 1922, April, p. 529).

It is not proposed to say more about the resemblance between Paget's disease and rodent ulcer than that they resemble each other by beginning in the same layers of epithelium, in the occasional occurrence of epithelial cell nests, and in that in each the permeation of lymphatic vessels must be exceedingly rare.

Fig. 196 is included to show that acini can be present in the nipple, and that, therefore, a carcinoma beginning in the nipple may be acinous and not necessarily of duct origin. This nipple is full of secreting acini which extend up to the true skin of its surface. The specimen came from a lactating breast of a woman three months after parturition.

SITE OF ORIGIN OF PAGET'S DISEASE OF THE NIPPLE.

It is now my object to show that Paget's disease begins as a primary disease in epithelial cells situated above an imaginary line drawn parallel with the surface of the nipple immediately below the expansions that occur in the mammary ducts before they terminate upon the surface of that structure. In addition, attention is drawn to certain facts suggesting that a common site of origin is possibly in the outlet of a mammary duct.

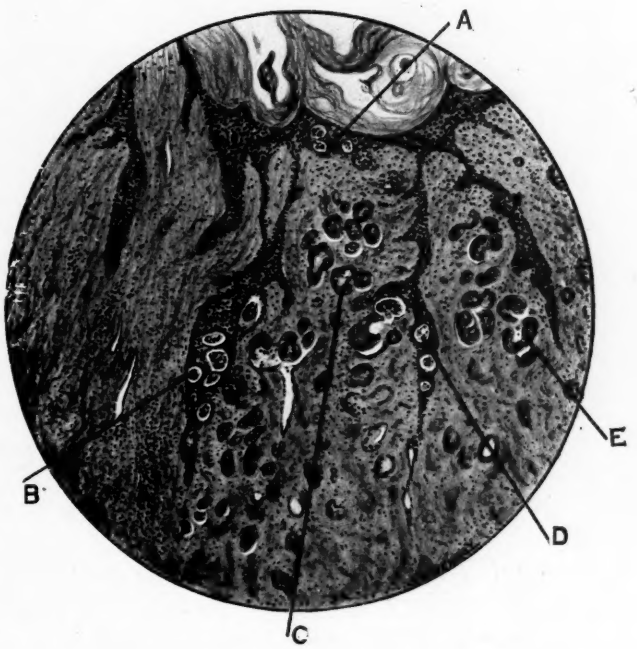


FIG. 197.—Upward growth of a carcinoma, C and E, originating below the line to which I refer in the text (*see Fig.* 191). A is the surface epithelium of the nipple, in which foci of the carcinoma can be seen; collections of cells from C and E can also be seen in the surface epithelium at B and D: the surface epithelium has not undergone any changes excepting those due to pressure of the invading cells of the tumour.

First, it may be stated that a carcinoma beginning below that line is very rarely associated with Paget's disease of the nipple. This is so in spite of the fact that many carcinomata grow in masses right into the nipples and reach the epithelial surfaces without inducing any changes in them. In other specimens the lymphatic vessels of the nipples are permeated with carcinoma

cells in small or great degrees, also without any signs of Paget's disease. A carcinoma arising in the breast below that line may in some instances actually invade only the basal layers of the epidermis of the nipple, or in others it may even invade the whole of the epidermis of that structure without inducing any change apart from the effect of pressure (*Fig.* 197).

I now describe two examples of quite superficial carcinoma that began in the nipples just below the imaginary line without inducing Paget's disease. The first specimen is that which Sir Hugh Rigby kindly allows me to publish of a duct carcinoma of the breast. There was no Paget's

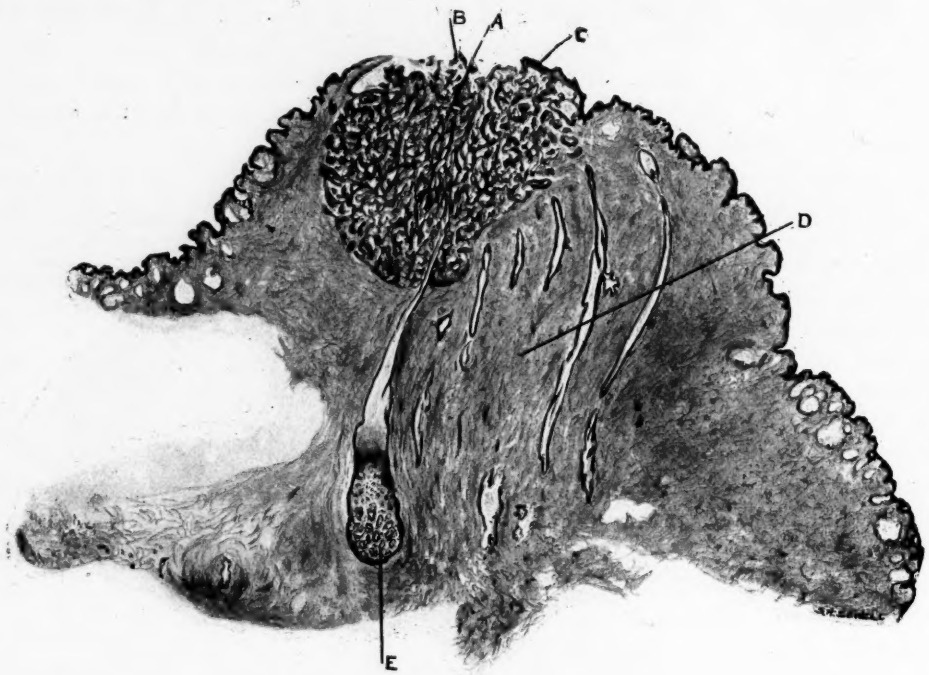


FIG. 198.—Low-power reproduction of the nipple and contained duct carcinoma from a patient under the care of Sir Hugh Rigby. The surface epithelium of the nipple which is intact at B, C, shows no sign of Paget's disease; E is a duct containing a large, multiradicular papilloma of doubtful nature; the tumour began below the imaginary line DE of *Fig.* 191.

disease (*Fig.* 198). The carcinoma was of a particularly malignant type, and the axillary lymphatic glands were implicated. The primary tumour was in the nipple, and was so small that its detection required careful palpation. There was hæmorrhage from the nipple. The patient was unmarried, age 36 years.

The pathological report was: "Tubular and intratubular papillary cuboidal cells, rarely squamous and horny, carcinoma of duct of nipple." There is also a large multiradicular papilloma existing in the duct at E, *Fig.* 198. The papilloma is not in continuity with the tumour above it. The surface epithelium has been shed in parts; in other parts where it is covering the papillæ of the true skin it is either perfectly normal or has

been killed *in situ*, without undergoing Paget's disease. I have another almost precisely similar specimen (*Fig.* 199). The portion of surface epithelium selected for reproduction is typical of the whole of the surface from which it came. This tumour also began just below the imaginary line without inducing Paget's disease. Here are two wonderful examples of a common and usual state of things.

In the whole of my collection I have only one specimen that can support the view that Paget's disease of the nipple is a secondary consequence to the upward spread of a subjacent carcinoma. I reproduce it in *Fig.* 200, where Paget's disease is affecting only a few basal cells in the epidermis of the nipple, and a duct wall. The basal cells have separated from each other; they have lost their prickles; they have become vacuolated; and, after multiplication, they have invaded deeper tissues. A few concentric cell inclusions can be seen. This is the smallest lesion of the kind I have seen, and it induced no visible clinical change in the top of the nipple where it was situated. Dr. Arthur Whitfield and I consider it to be an early Paget's disease of the nipple. The breast contained a large carcinoma that extended up to the side of the areola. The nipple was free from invasion by this carcinoma. This specimen might be regarded by some as evidence in support of the idea that Paget's disease is due to the previous existence of subjacent carcinoma. It would be difficult, however, to believe that so large an underlying carcinoma had induced so minute an area of Paget's disease.

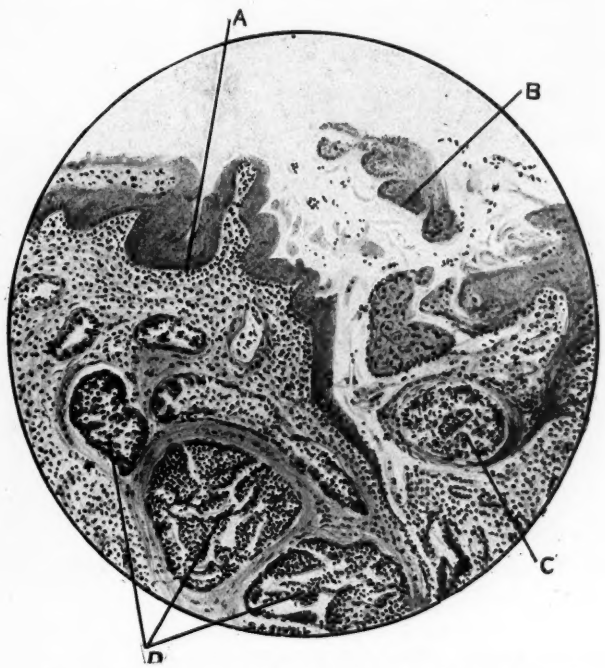


FIG. 199.—Low-power reproduction of a duct carcinoma of the nipple (female) which began below the line DE of *Fig.* 191. The surface epithelium was intact at A and B, and shows no sign of Paget's disease; lymphatic vessels below the surface epithelium of the nipple are filled with carcinoma.

My explanation of the pathological changes in this specimen will be seen later to be as follows: Paget's disease of the nipple is carcinoma which, in this instance, has either begun independently, or possibly, as an exception to my rule, has occurred as a primary disease as a result of the action of the same agents that induced the underlying carcinoma of the breast.

I am glad to say many authorities agree with me in describing as carcinoma a process of epithelial hyperplasia that is considered by others not to be carcinoma. To make myself clear I will attempt to show how it

is that there is an element of disagreement on the subject. Take the upper part of the longitudinal duct in *Fig.* 207, and imagine a transverse section of it at **E**; it would have shown a dilated duct full of multiplying epithelial cells, abnormal in character, which show no evidence of invading the connective tissues. Therefore it is said that the contents of the duct cannot be carcinoma. Now imagine that another transverse section of this duct had been made at **A** in *Fig.* 207. Here a dilated duct full of the same growth would have been seen, but at one point invasion of the duct walls is so perfectly obvious that all would agree that the lesion is carcinoma. My opinion is that carcinoma is present in both of the imaginary transverse

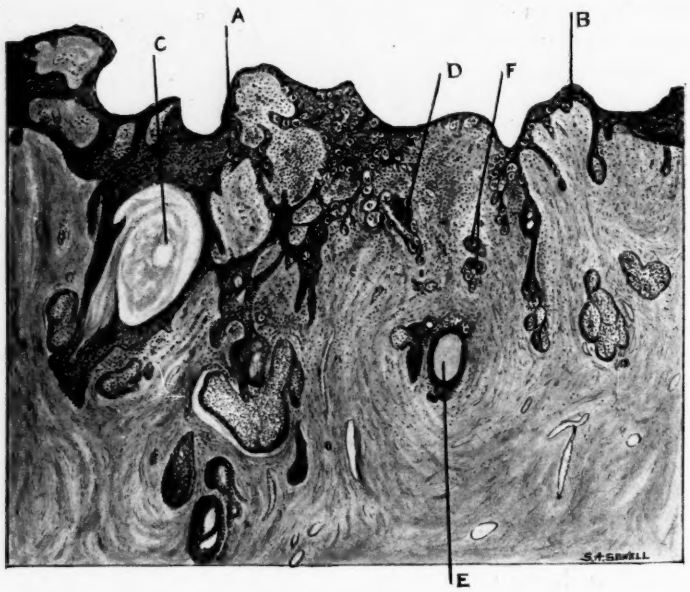


FIG. 200.—Low-power reproduction of top of the nipple with the smallest area affected by Paget's disease (between **A** and **B**) that I have ever seen. A mass of subjacent carcinoma was growing upwards from the subjacent breast which had reached the areola on one side of this nipple; there was no carcinoma of the nipple excepting the Paget's disease of its epithelium; **D** is Paget's disease of the nipple where the invasion is most marked; **E** is the affected and plugged termination of a duct just before it reaches its outlet; **F** is the edge of the affected outlet into which **E** leads; epithelial cells from **E** and **F** are invading the surrounding structure; **C** is a plugged duct outlet, but otherwise is normal.

sections. I humbly believe that many of those who disagree with me now will agree with me when they become more fully acquainted with all that whole sections of breasts can teach them.

I will now produce further evidence to show that Paget's disease begins as a primary disease in the epithelium situated above the imaginary line already indicated. It would be interesting, and perhaps more conclusive to my thesis that the breast carcinoma is secondary to the Paget's disease of the nipple, if I could show a specimen of the latter that was not associated with the former. Failing this evidence, it is important to point out that the condition does occur elsewhere than in the nipple as a primary disease and in the absence of any other form of carcinoma; for example, see

Fig. 201. During six years Paget's disease of the nipple had been slowly spreading in the skin covering this patient's abdomen, in the absence of any other form of carcinoma in the body. The lesion here depicted was carefully examined microscopically.

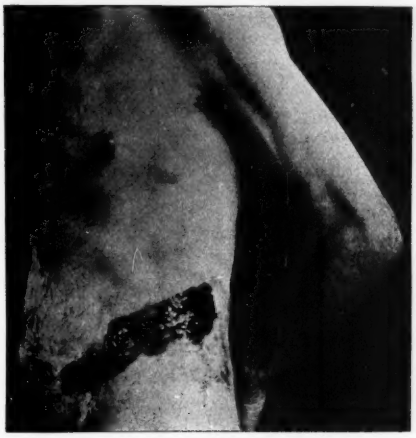


FIG. 201.—Paget's disease of the nipple on the abdomen of a man, age 49. The disease was carefully examined microscopically. The lesion had been spreading for six years. I published this photograph previously, in order to show the limitation of the lesion to the tenth dorsal nerve area. Excepting for the presence of this disease, there was no carcinoma in the body for six years.

To prevent constant repetition I may say at once that I have no specimen that does not show in at least one duct the changes seen in the duct at **B** in *Fig.* 210. There is evidence in all of a direct continuity between carcinoma in a duct and in the disease on the surface; the continuity of disease may not persist and is liable to reappear after interruption (*Fig.* 216). These facts could be taken as arguments in favour of Paget's disease of the nipple being a secondary disease to the presence of carcinoma in the upper duct region. Such arguments are refuted by the statement that if the carcinoma in the duct were primary and Paget's disease were secondary, then the latter would be a common and not a rare condition. Also the fact must be borne in mind that Paget's disease can be multicentric in origin, and foci of multicentric origin occur in parts on the surface of the nipple that are not in continuity with carcinoma in a duct (*Fig.* 213).

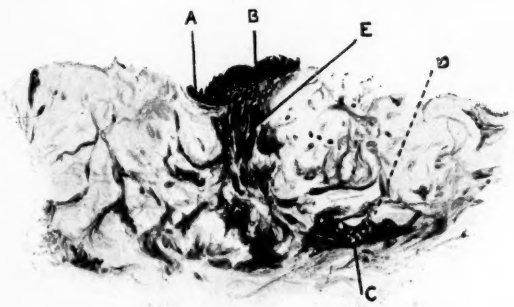


FIG. 202.—Elastica-stained whole section of Paget's disease of the nipple. Female, age 48, married. Between **A** and **B** is the nipple, and at **A** part of the areola. **A** and **B** mark the limit of the disease. **C** marks the position of a duct and its branches full of a multiradicular papilloma which is seen under higher magnification at **A** and **C** in *Fig.* 204. **E** is the duct of which **C** is a continuation. There is no carcinoma in the upper parts of **E** nor in any of the other ducts of the nipple. The elastica in **E** has undergone greater hyperplasia than any other duct in the breast. The dotted line **D** marks the position of the acinous carcinoma in the next section of the series, which is seen at **A** in *Fig.* 203.

An extensive Paget's disease of the nipple is reproduced in *Fig.* 202. The whole of the normal surface epithelium of the nipple and that of a large area of the areola has been destroyed by the disease. Apart from the carcinoma in the upper regions of two ducts, after an exhaustive search for a further carcinoma of the breast I discovered an unsuspected small area not bigger than a split pea at **A**, *Fig.* 203, in the depths of the gland. It had only infiltrated the connective tissue around it. In no part of the breast were there any permeated lymphatic vessels, and therefore the lymphatic vessels

subjacent to the diseased area on the surface contained no carcinoma. In a duct at **C**, *Fig.* 202, there was an extensive and unsuspected multiradicular papilloma, the cells of which were all contained within the duct (*Fig.* 204). It may be an example of an early duct carcinoma, but if it be, it is one that has not transgressed the natural boundaries of the duct. The difficulty in assuming these tumour formations to be an inducing factor of the Paget's disease on the surface is too great. I can only believe that the disease on the surface of the nipple was primary.

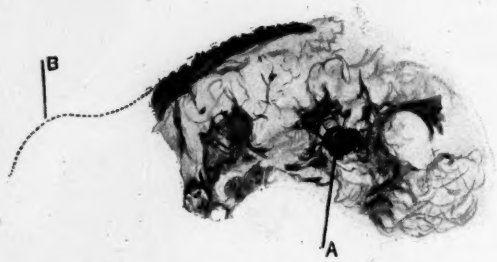


FIG. 203.—Reproduction of the next section in the series to *Fig.* 202 situated at the position of the dotted line **D** in *Fig.* 202. **A**, The acinous carcinoma (two-thirds natural size) to which reference was made in describing *Fig.* 202. The carcinoma is infiltrating the surrounding tissue. **B** represents the position of the nipple. In no parts of the breast were any lymphatic vessels to be seen containing carcinoma. Besides the Paget's disease of the nipple and carcinoma **A**, no other carcinoma existed in this breast, unless the multiradicular papilloma, **A** and **C** in *Fig.* 204, contain a duct carcinoma.

Another specimen of Paget's disease of the nipple, about the same in extent as that in the above figures, is reproduced in *Fig.* 205. In a segment of this breast there is much epithelial activity in the acini (*Fig.* 205 at **E** and *Fig.* 206 at **A**), as well as in one duct (*Fig.* 205, **D**). In another duct there is a limited activity of epithelium which is in continuity with the disease in its outlet (*Fig.* 194). The outlet is common to both these ducts (*Fig.* 193). It is interesting to observe in these two ducts that there is so much more epithelial activity in one than in the other. I believe carcinoma exists in both ducts, but while in *Fig.* 207 it has reached the stage of invading the walls of the duct, in *Fig.* 194 it is still limited to the natural walls of the duct. There is another fact to be observed in that part of the disease which has spread to the areola, viz., the ducts of the sebaceous glands and the hair follicles have been attacked by Paget's disease of the nipple (*Fig.* 208). I could not discover permeation of lymphatic vessels by carcinoma cells in any part of this breast. Again, it is difficult to assume that the carcinoma in this breast could have induced the Paget's disease.

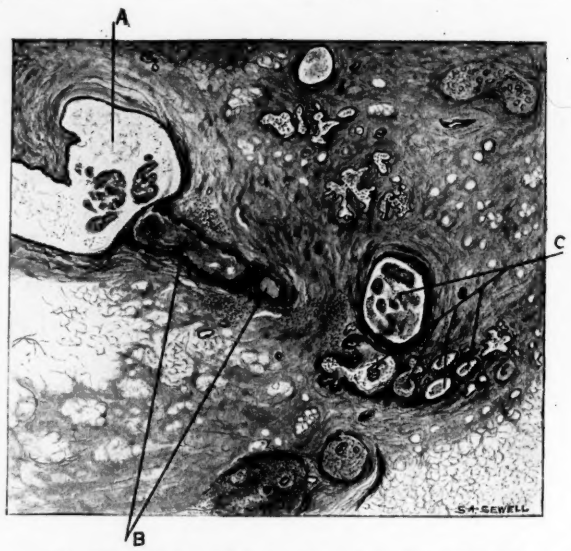


FIG. 204.—**A**, **B**, and **C** are branches of the duct **C** in *Fig.* 202 under higher magnification. **A** and **C** can be seen full of multiradicular papilloma. Part of the duct, **B**, contains semi-organized tissue containing a few connective-tissue cells embedded in fibrinous-looking material. It may be the result of a hæmorrhage. There are no epithelial cells in this part of the duct.

Fig. 209 represents a small lesion of Paget's disease limited to the top of the nipple. Two mammary duct outlets are affected with Paget's disease. In one only (*Fig.* 210) is carcinoma present in the duct belonging to it. After examining whole sections of this breast I could find no other carcinoma, except a few lymphatic vessels that were blocked by carcinoma cells (*Fig.* 210, **D**). These cells, therefore, must have originated in the small amount of carcinoma in the duct at *Fig.* 210, **B**.

In all the above specimens, which are examples of the usual conditions, it would be more likely that the superficial disease had attacked the widely separated deeper structures as it spread to them one after the other, than that the deeper parts had all become affected one after the other and had then induced the superficial disease.

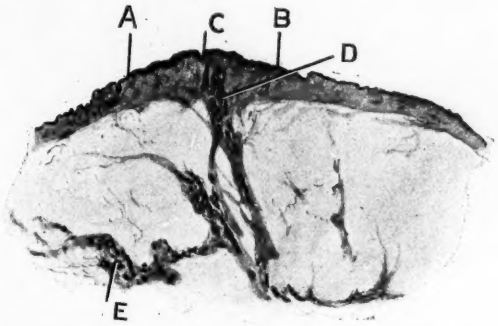


FIG. 205.—Whole section of breast affected by Paget's disease of the nipple. Female, age 49, married. **A** and **B** mark the limit of the disease, which included the areola. **C** is the centre of the nipple. **D** is a duct containing duct carcinoma. **E**, Acini that have become carcinomatous. No lymphatic vessels containing carcinoma cells could be discovered.

It may have been noticed that while describing these breasts I have stated that in those shown in *Figs.* 203 and 205 I could not discover any lymphatic vessels containing carcinoma cells, and in that description I included those lymphatic vessels that lie beneath the Paget's disease.

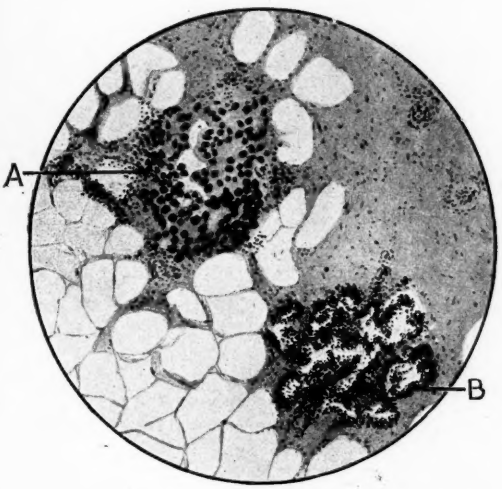


FIG. 206.—Reproduction under high power from **E**, *Fig.* 205. At **A** carcinoma can be seen beginning to invade the connective tissue round the acinus. **B**, A lobule the acini of which contain desquamative epithelial hyperplasia.

I may misunderstand Mr. Sampson Handley's explanation of Paget's disease of the nipple[1] when I assume that he attributes the disease to the plugging of the subjacent lymphatic vessels by carcinoma cells. I have just shown two specimens of Paget's disease of the nipple in which the carcinoma in the breast had not reached any lymphatic vessels; therefore the nipple disease could not have been due to that cause. I have four other specimens in which some lymphatic vessels situated in other parts of the breast are certainly permeated—for example, *Fig.* 219, from *Fig.* 218, **G**—but the whole of the nipples and their areola are absolutely free from carcinoma cells.

It is quite obvious that Paget's disease of the nipple occurs without any permeation by carcinoma cells of the subjacent lymphatic vessels. On the

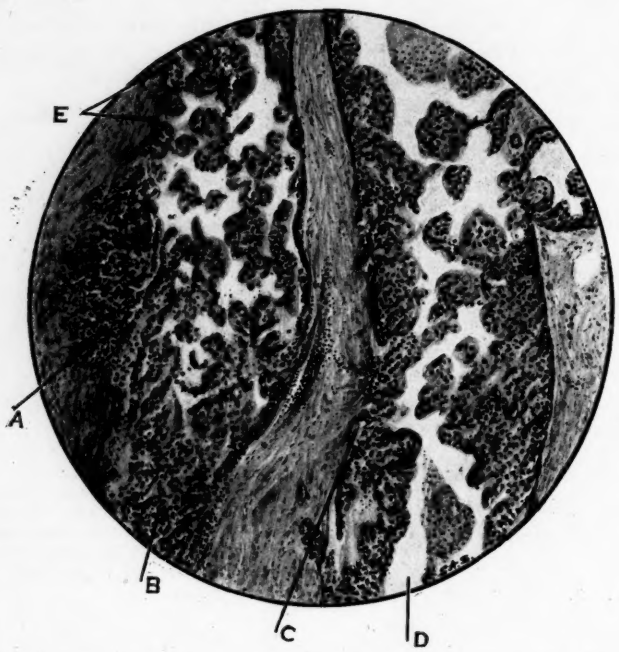


FIG. 207.—Columnar-cell carcinoma occurring in two branches of the duct at D in *Fig.* 205. There is invasion of the surrounding connective tissue in the branch B at A and in the branch D at C. E marks a place where in the text I ask the reader to imagine that the duct has been cut transversely and to compare it with an imaginary transverse section cut at A,

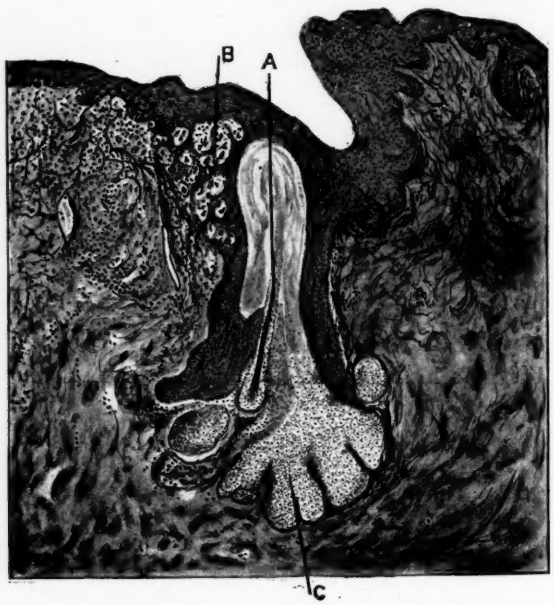


FIG. 208.—A hair follicle with its sebaceous glands reproduced under high power from the margin of the Paget's disease of the nipple of *Fig.* 205 at B. Paget's disease of the nipple can be seen affecting the basal layer of this hair follicle at C. A is the hair. B, Paget's disease of the nipple.

other hand, the vast majority of specimens in which these lymphatic vessels are plugged with carcinoma cells show no sign of Paget's disease. Moreover the condition can occur elsewhere on the body as a primary disease and in the absence of all other forms of carcinoma.

I pass on to draw attention to certain facts that suggest a close connection between the origin of Paget's disease of the nipple and the outlets of mammary ducts.

As Paget's disease of the nipple begins on the top of that structure (*Figs.* 200 and 209) and not on its sides nor in the areola, it seems reasonable to assume that the duct outlets, which are limited to this portion, must play some essential part. By the irritation consequent on their closure by plugs,

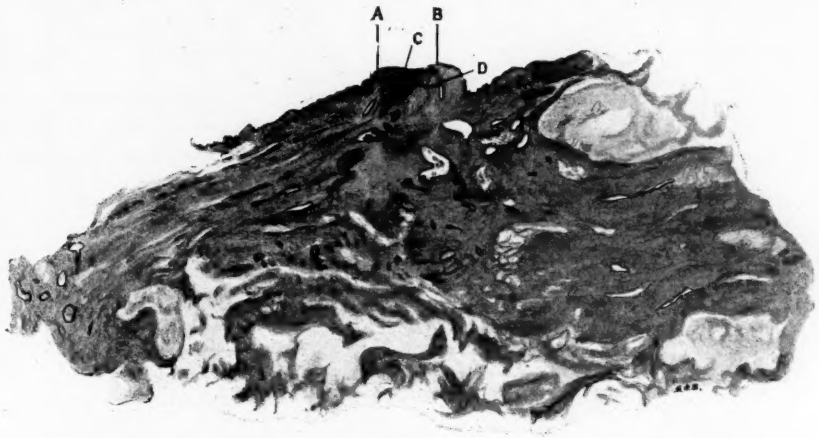


FIG. 209.—Whole section of breast affected by Paget's disease of the nipple. Female, age 52, married. Lines **A** and **B** mark the limit of the disease. **C** is a mammary duct outlet which leads into the affected duct that opens into it. The duct is full of carcinoma and is represented in the figure by four black marks. **D** is a plugged duct outlet affected by Paget's disease of the nipple. The duct which ended in this outlet did not contain carcinoma. A branch is cut longitudinally and lies a little below it. Above the duct outlet there were some lymphatic vessels plugged with carcinoma cells which must have been derived from the carcinoma in the duct leading into the outlet at **C**.

they appear to me to afford the essential explanation of the induction of Paget's disease.

In *Fig.* 210, **C**, will be seen a duct outlet blocked by a plug surrounded by Paget's disease of the nipple with no corresponding lesion on the surface epithelium at this part. In the same figure at **A** a similar blocked duct outlet is present, but in this instance the deeper duct (*Fig.* 210, **B**) with which it is continuous contains early carcinoma, which was absent from the deeper duct belonging to *Fig.* 210, **C**.

To complete this part of my article I must add that, had it not been for the early disappearance of almost all sebaceous glands in Paget's disease of the nipple, there might be some evidence to show that it can begin in the basal epithelium of their ducts as they enter the outlets of mammary ducts or terminate upon the surface of the nipple.

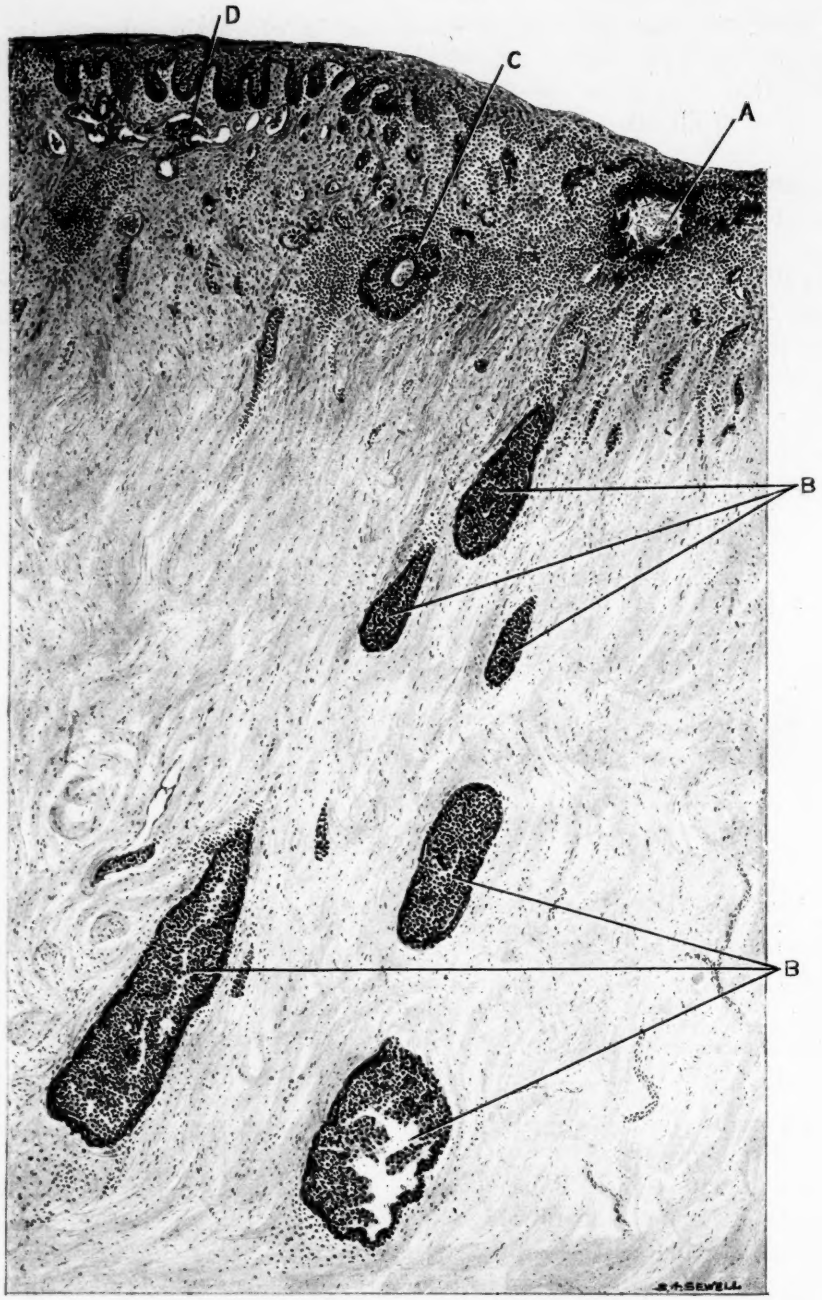


FIG. 210.—A higher magnification of part of the nipple shown in *Fig.* 209. A is a plugged duct outlet which is affected by Paget's disease of the nipple. The epidermis covering it is not affected by this disease. It appears that Paget's disease began in this duct outlet. B is the carcinoma of the duct. Its opening on the surface is not shown in this section. No trace of invasion of the connective tissues by carcinoma can be seen. C is another duct outlet affected by Paget's disease of the nipple. Its opening on the surface is not seen in this section. The duct which led into it did not contain carcinoma. It appears that Paget's disease of the nipple began also in this duct outlet. On the surface of the nipple Paget's disease existed, but it is not shown in this section. D, A lymphatic plug with carcinoma cells which must have been derived from carcinoma in the duct B, as no other carcinoma except Paget's disease of the nipple existed in the breast.

THE PATHOLOGICAL APPEARANCES IN PAGET'S DISEASE OF THE NIPPLE.

Having drawn attention to the fact that the disease is a primary disease in the nipple as well as elsewhere in the body, I pass on to describe the disease as it affects the nipple, and to show, incidentally, reasons why I am convinced it is carcinoma. Sometimes the disease affects an isolated area which is not in continuity with any part of the main disease that exists elsewhere in the nipple (*Figs.* 211 and 212). The specimen not only affords an example of the multicentric origin, but it also affords a beautiful example of the disease in the early stage. A few cells of the basal layers of epithelium have become separated from one another; they have become vacuolated; they have lost their prickles; and among them can be seen an epithelial cell undergoing mitosis. These are the earliest visible indications of the disease, and the presence of a mitotic figure indicates a process of epithelial activity.*

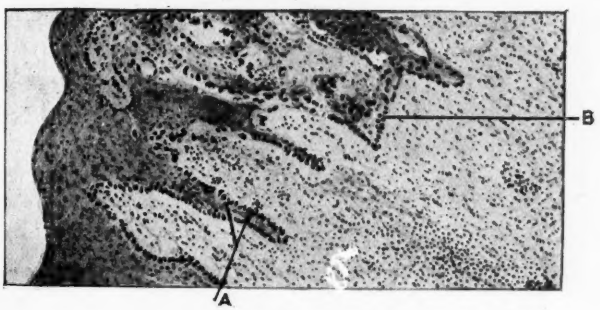


FIG. 211.—The edge of an isolated area of Paget's disease of the nipple in the disease of the surface shown in *Fig.* 202. A is the extreme limit of the disease, and B shows invasion of basal epithelial cells after their multiplication. (*See also Fig.* 212.)

Fig. 213 shows another isolated area of early disease, reproduced from

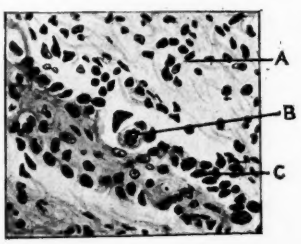


FIG. 212.—Reproduction under higher power of A in *Fig.* 211. A, Connective tissue. C, Epithelial cells which can be seen separated from each other. They have lost their prickles, they have multiplied, and on the extreme left of the section a cell has become vacuolated. At B there is an epithelial cell undergoing mitosis. These appearances represent the earliest stages to be observed in Paget's disease of the nipple.

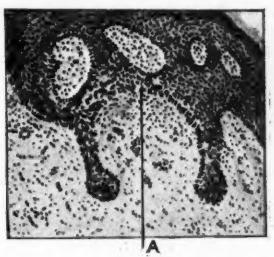


FIG. 213.—Shows an isolated area of Paget's disease of the nipple in an early stage, from *Fig.* 202. It is not in continuity with the main disease, but Paget's disease of the nipple can be multicentric in origin. At A the cells have multiplied, lost their prickles, become vacuolated, and separated from one another. There is no mitosis in this section.

* I would not attach importance to mitosis as a sign of malignancy when it occurs in papillomatous tumours that are not invading deeper tissues. When it occurs in epithelial cells massed together in no particular arrangement, as in *Fig.* 212, I believe the presence of mitotic figures is evidence of profoundly serious import, especially when in parts of the same disease the epithelial cells are invading deeper tissues. Some of the slowest-growing tumours have many mitotic figures, and some of the most rapidly-growing tumours exhibit only a mitosis. Paget's disease of the nipple is not usually a malignant type of carcinoma, and in many of the epithelial cells massed together in no particular arrangement there are many mitotic figures; sometimes six can be seen in one field of a one-sixth objective.

another specimen. In this particular collection of cells mitosis is absent. *Fig.* 214 from *Fig.* 215, E, is taken from the spreading margin of the main

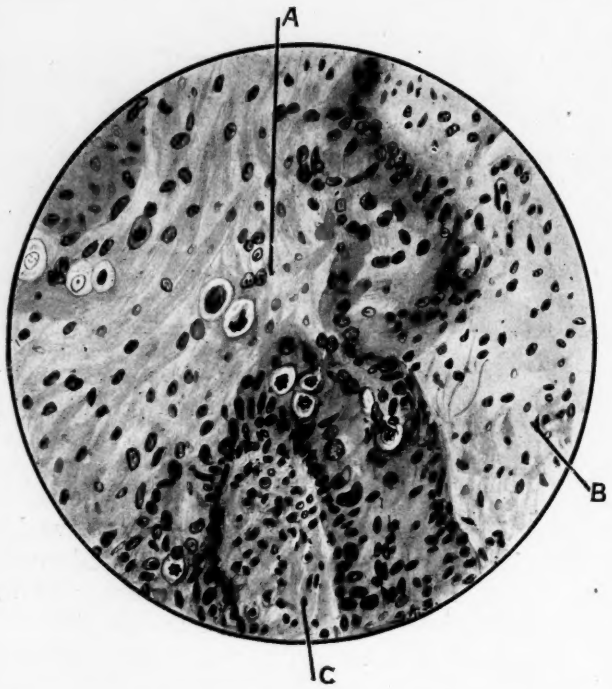
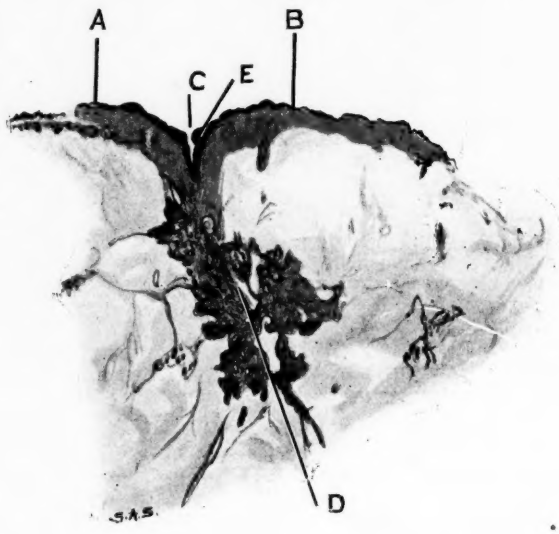


FIG. 214.—The edge of a duct outlet affected by Paget's disease of the nipple, from E, *Fig.* 215. B and C are connective tissue. A points to the affected basal layer of epithelial cells, among which six mitotic figures are seen. The drawing does more justice to the appearance of the mitotic figures than it does to the appearance of Paget's disease of the nipple.

disease in a duct outlet, and the appearances seen in *Fig.* 212 are repeated in every detail, except that mitotic figures are more numerous in *Fig.* 214.

FIG. 215.—Whole section of a breast affected by Paget's disease of the nipple. Female, age 53. A and B mark the limits of the disease; C points to the centre of the nipple and to a duct outlet destroyed by the disease, this duct leading to the greatest amount of carcinoma found in the breast, D. There were no lymphatic vessels containing carcinoma in the remains of the retracted nipple and areola. E indicates the area seen under higher magnification in *Fig*, 214.



Between all of these lesions and the subjacent elastica, connective-tissue hyperplasia has already taken place (*Fig.* 216, C), and in the older regions of

the disease hyperplasia of the connective tissue can be seen occurring in the midst of the elastica and outside its boundaries in varying degrees (*Fig.* 216, **B**). I regard these connective tissues as being purely secondary in character.

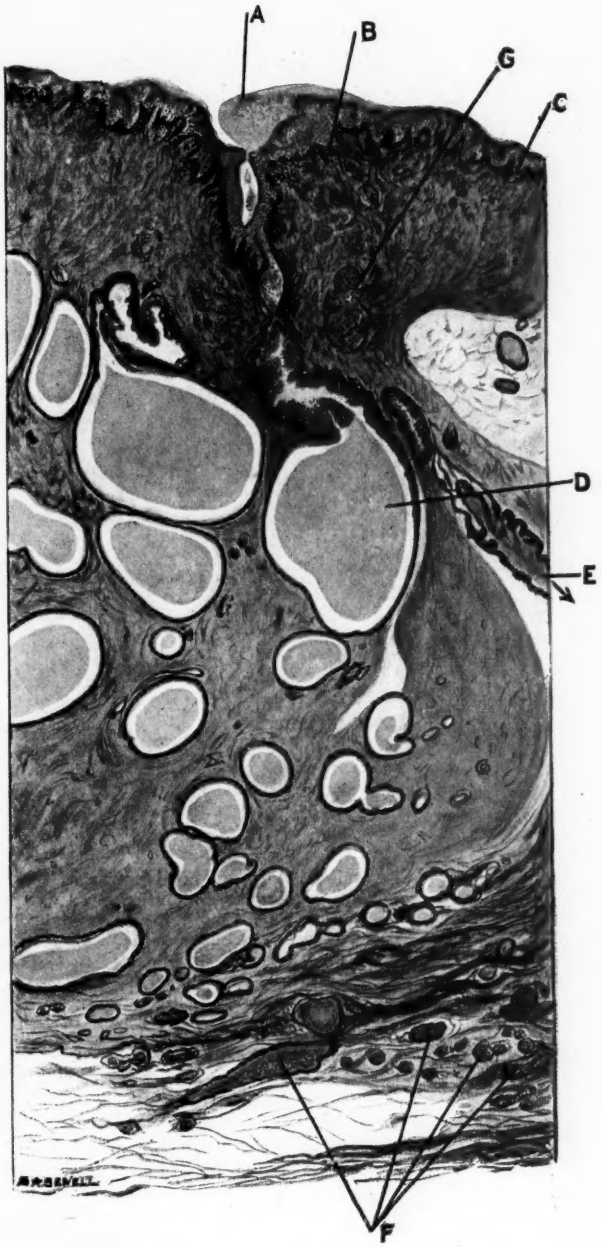


FIG. 216.—Part of a whole section of a breast affected by Paget's disease of the nipple. Female, age 53, married. Elastica stained. The disease is affecting the whole of the nipple and most of the areola; this reproduction does not quite include its boundaries. **A** is a plugged duct outlet affected like the surface of the nipple with Paget's disease. The duct leading into it has been cut longitudinally and can be seen to be filled with carcinoma. Further, it is leading directly into a cyst (or dilated part of the duct) at **D**, to the upper part of which the carcinoma is limited; lower down in the breast, carcinoma reappears in the same duct distribution at **F**, in acini, branches of the duct, and lymphatic vessels; **G** is another duct which contains carcinoma, which, however, had not spread to the deeper part of the gland; **C** is the elastica, between which and the surface disease hyperplasia of the connective tissue is taking place; at **B**, where the process is older, the hyperplasia of the connective tissue is no longer limited by the elastica and has spread beyond it; **E** is a longitudinal section of a blood-vessel which extends to the periphery of the breast and was filled by blood-clot in an early stage of organization. As I explain in the text, the disease attacked a nipple of a proemial breast in which the cysts encouraged the widespread distribution of the carcinoma. Many lymphatic vessels in the breast contained carcinoma. No disease could be discovered in the axillary glands.

The epithelial changes already described may in parts develop very slowly, while in other parts comparatively large masses of closely-packed epithelial cells have formed as a result of their multiplication. In *Fig.* 217

can be seen many mitotic figures. The masses of epithelial cells are never great enough to cause a fungating appearance on the diseased surface, which always remains, clinically, smooth, level, and firm, somewhat resembling, in miniature, a hard lawn-tennis court. With the multiplication of the epithelial cells, invasion by them of deeper tissues undoubtedly occurs (*Fig.* 217). At the margins of the growth there often exists a line of cuboidal or flattened elongated epithelial cells which suggest the appearance of an edge that is not invading deeper structures, but as the cells are epithelial they form part of the invading mass. In the middle of the diseased part epithelial cells can be seen including within them concentric bodies which compress the nuclei into semilunar shapes. The presence of these concentric cell inclusions is supposed by most to be typical, to be observed only in Paget's disease of the nipple. Occasionally an epithelial cell nest can be seen. Although the disease begins in the pigment cell layers, the tumour that results from their multiplication is not pigmented. When Paget's disease of the nipple occurs elsewhere in the body, it rarely, if ever, permeates lymphatic vessels, although the cells of the lesion invade deeper tissues. In this respect the condition resembles rodent ulcer. It would seem that when permeation occurs in the lymphatic vessels which underlie a Paget's disease of the nipple, the permeating carcinoma cells must be derived from a carcinoma in the breast. Retraction of the nipple is the cause of an apparent disappearance of that structure; when its real disappearance occurs, it is doubtless caused by the invasion of epithelial cells, the chronic infective process that accompanies it, and the atrophy of the musculature.

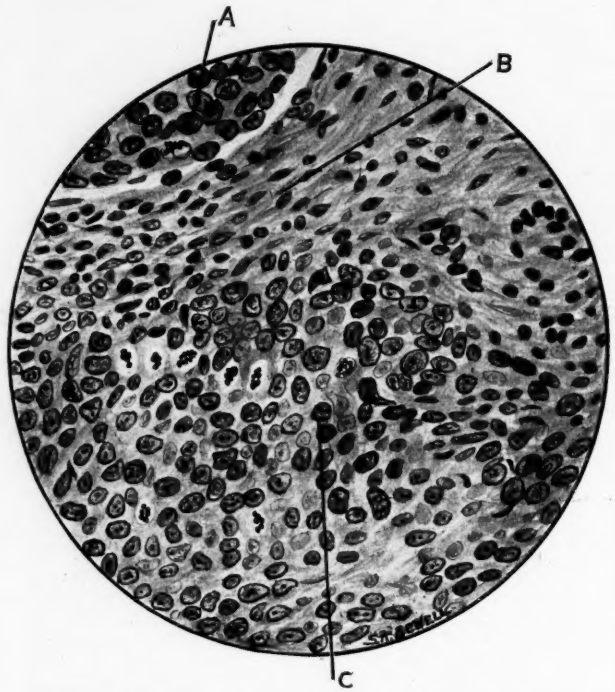


FIG. 217.—Reproduction under high power of a comparatively large collection of cells at one part of a nipple affected by Paget's disease. B is the connective tissue that is being invaded by the disease as seen at A and C; in the mass of diseased cells at A, one mitosis is seen; in the mass of disease at C, eight mitotic figures are seen.

THE CARCINOMA IN THE BREAST.

I have already stated that I have not yet been able to discover a Paget's disease of the nipple that was not associated with carcinoma in the breast.

I have no evidence to show that a proemial breast is more liable than

any other to be attacked by Paget's disease. I have evidence that when carcinoma attacks a proemial breast in which Paget's disease is present, the spread of the carcinoma in the glandular elements is very extensive (*Fig.* 216). My explanation of this fact is that the dilated cystic state of the ducts allows a free distribution of the agents that induce carcinoma. The fact that carcinoma in the breast is so commonly associated with Paget's disease of the nipple at once makes one suppose that there is a definite connection between them, and indeed there must be. I propose to discuss what that connection is; but before doing so there are two facts to which I must draw attention. The first is that the associated carcinoma in the breast varies with the types of epithelial cells that are affected. For instance, *Fig.* 194 shows a type of disease somewhat similar to Paget's disease of the nipple, the only difference being an absence of the concentric bodies so typical of that condition. In the normal state the epithelium of this part of the duct is in the process of changing in type from squamous to columnar. The columnar type has not become definitely established. In the lower parts of the nipple the epithelium of the ducts is definitely columnar, and when these parts are attacked the carcinoma is a duct carcinoma (*Fig.* 207). When the acini are affected, as they are at **E** in *Fig.* 205, at **A** in *Fig.* 203, and at **D** and **E** in *Fig.* 218, the disease is not recognizable as a columnar-celled carcinoma. It is possible for four types of carcinoma to exist in the same breast, viz.: (1) Paget's disease of the nipple; (2) The somewhat similar disease in the upper duct; (3) Columnar-celled carcinoma; and (4) Acinous carcinoma. They all occurred in the breast reproduced in *Fig.* 205. Also *Fig.* 202 shows that in one breast there were Paget's disease of the nipple, a slightly altered and somewhat similar disease in the upper regions of two ducts, a large multiradicular papilloma the precise nature of which is decidedly doubtful, and an acinous carcinoma. The other five breasts are equally interesting from this point of view.

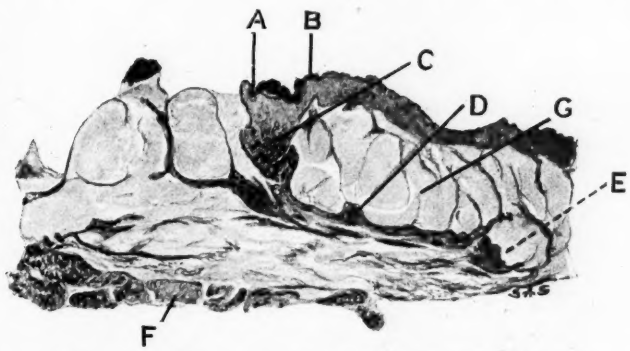


FIG. 218.—Whole section of breast affected by Paget's disease of the nipple. Female, age 51, married. **A** and **B** mark the limits of the disease; at **C** are branches of more than one duct that are filled with columnar-celled carcinoma; at **D** is a small area of carcinoma that is infiltrating the surrounding connective tissue. The dotted line **E** points to another and similar focus of carcinoma in the gland that was discovered a section or two lower in the series. **F** is the pectoralis major. Lymphatic vessels were permeated by carcinoma cells. The lymphatic vessels of the nipple and areola were not thus permeated. **G** marks the part in the fat from which *Fig.* 219 is reproduced under high power; on reference to *Fig.* 219, it will be seen that a nerve contains carcinoma, and that the lymphatic vessels are permeated by carcinoma. The nipple, **A** and **B**, is markedly retracted.

The second fact is that the carcinoma in all parts of the breast is not always in direct continuity with the Paget's disease (*Fig.* 216).

Induction of carcinoma in the subjacent breast could occur in one of three ways.

1. The superficial tumour (Paget's disease of the nipple) may grow downwards, using the mammary ducts as its pathways, in the same manner as lymphatic vessels act as viaducts for carcinoma. In *Fig.* 194 an early implication of the upper part of a mammary duct has occurred. There is no normal epithelium lining this part of the duct. If this duct were acting merely as a pathway for a downward-growing tumour, a normal epithelial lining should be present, especially in such an early stage. No such thing can be seen. Its appearances do more than contradict the possibility of a downward growth; they indicate that the epithelium which, when normal, lines the upper part of this duct, is now in the early state of primary disease. This leads to another point. The carcinoma that affects parts of the breasts that are deeper than the upper duct region bears no resemblance to the carcinoma on the surface. The carcinoma that grows in the deeper parts of the breast does not look like Paget's disease of the nipple and has no concentric cell inclusions, and by affecting lymphatic glands and the body generally shows that it may be much more malignant than that disease. If it were a downgrowth of a tumour, normal epithelial structures would be surrounding the tumour, but there are no signs of them. On the contrary, the normal structures have become carcinoma. There must be something more than merely a downward growth of a tumour, because in *Fig.* 216 at **D** there is an abrupt solution in the continuity of the tumour process, which reappears in the terminations of the same duct at **F**. To explain this fact it would be necessary to invoke the aid of another possible factor described in the next paragraph.

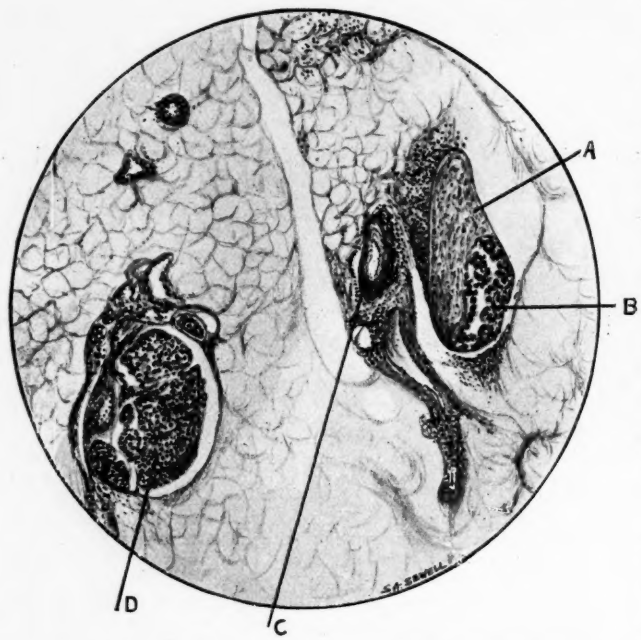


FIG. 219.—A reproduction under high power of the part **G** in *Fig.* 218. **A** is a nerve-fibre in which there is a mass of carcinoma, **B**; the perivascular lymphatic vessels at **C** are permeated by carcinoma; at **D** is a large mass of carcinoma in transverse sections of lymphatic vessels.

2. It may be that portions of the disease upon the surface are detached and by means of transplantation become grafted in the deeper parts of the breast and grow there. In *Fig.* 194, **D**, there is a clump of a dozen epithelial cells which look as though they might have been detached from a growth elsewhere and had then started to grow in their new situation. Assuming that this has occurred, it must be admitted that the graft was detached from the growth in the duct, and that growth is not identical with

that of the Paget's disease of the nipple. *Figs.* 203, 206, 207, 209, 215, 216, 218, and 220 show the same difference in character between carcinoma in the breast and Paget's disease on the surface. On the whole, the theories that a tumour in the breast is the same growth that has spread from the surface, either by natural pathways or by transplantation, cannot be accepted. It is therefore necessary to propose in the next paragraph another interesting and more important explanation.

3. The agents of irritation that induce Paget's disease of the nipple may also be concerned in the induction of the primary carcinoma in the epithelial cells of the breast, to which the agents of induction are distributed by means of the mammary ducts.

There are a good many criticisms that can be adduced against this thesis. For instance, why are not the sweat glands affected by carcinoma when Paget's disease of the nipple reaches the skin? I cannot discover evidence that they are. Or if the agents of disease are capable of inducing a primary carcinoma of the breast, why cannot these same agents also induce Paget's disease of the nipple? If they could, the latter would be a common and not a rare disease. Or when a breast carcinoma spreads to the skin, why does it not induce a squamous epithelioma in the epidermis? Why is not the whole epithelium of the ducts and the acini all involved in primary carcinoma?

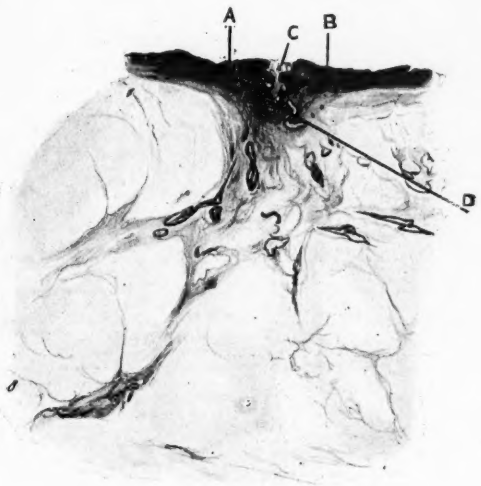


FIG. 220.—Part of a whole section of a breast affected by Paget's disease. Female, age 45, married. A and B mark the limits of the disease; C is the duct outlet mainly affected, leading to a duct carcinoma, the lowest limit of which is at D, which also represents the lowest limit at which carcinoma can be discovered in this breast; two more ducts are affected in lesser degree near the diseased surface epithelium. The lymphatic glands in the axilla were free from disease; lymphatic vessels adjacent to D were filled with carcinoma cells.

Figs. 200, 202, 205, 209, 215, 216, 218, and 220, in which the nipples are all affected with Paget's disease, show that carcinoma mainly affects one duct, although the degree of extension is different in each of the eight different breasts. The sections show this clearly, but it must not be assumed that other ducts are not attacked, for in the specimens shown they are attacked, though to a less extent. One reason for this disproportionate affection of one duct may be that its outlet was attacked by the disease at an earlier stage, and that therefore the disease in it made greater progress. This explanation does not appear to me to be complete. There are probably other reasons concerned with more complicated factors connected with the biology of cells; I do not now propose to enter into these problems further than to state that they are suggested by recent observations made by Dr. A. J. Murray, in which he mentions the difficulty of inducing a fresh area of tar carcinoma in a mouse that is already suffering from that disease.

However cogent the above criticisms appear to be, there are important reasons for placing limits to their application. For instance, carcinoma can be multicentric in origin: this occurs in Paget's disease of the nipple, in rodent ulcer, in squamous epithelioma, and before I knew of Dr. Archibald Leitch's impressive observation[2], I published reasons in this JOURNAL for stating that it also occurs in the carcinoma in breast epithelium. Dr. A. J. Murray's observation on tar carcinoma to which I have already alluded offers some explanation why multicentric origin does not occur more extensively when once it begins, and why there may be a limit to the number of cells attacked in the carcinoma process in the breast where Paget's disease of the nipple is also present. At the same time Dr. Murray's observation could be urged against the possibility of a multicentric origin of carcinoma. As it is known that multicentric origin of carcinoma does occur, Dr. Murray's perfectly accurate observation must have limits to its application. The work of Mr. A. J. Walton[3] and Dr. A. H. Drew[4] in this country, and of Carrel in America, offers important evidence to explain not only that multicentric origin of carcinoma occurs in the same type of epithelium, but also that primary carcinoma could be induced in other epithelial cells not strictly of the same type. Further investigations on similar lines are likely to demonstrate how the agents that induce Paget's disease of the nipple are concerned in the induction of the associated carcinoma in the breast.

PATHOLOGICAL CHANGES THAT ARE NOT MALIGNANT.

I must allude to changes other than carcinoma that can be seen in the breasts suffering from Paget's disease of the nipple. No doubt many of them were in existence before that disease began, for instance: desquamative hyperplasia of epithelium which led to the formation of cysts (*Fig.* 216); intra-elastica, elastica, and extra-elastica hyperplasia of connective tissue. There are other changes that are a direct result of Paget's disease of the nipple, such as the irritative hyperplasia of connective tissue that occurs first of all between the elastica and the superficial disease (*Fig.* 216) and then extends into and beyond the elastica. A remarkable fact about this hyperplasia is the presence of a great collection of plasma cells. Desquamative hyperplasia of epithelium of ducts and acini is marked in many parts, especially below the carcinoma in the gland. In *Fig.* 204 is a multiradicular papilloma* which is probably a result of the general irritation of the duct in which it is growing. In one or two breasts long tracts of blood-vessels have become completely

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* In "A Further Contribution to the Study of Cysts and Papillomata of the Breast", published in THE BRITISH JOURNAL OF SURGERY, 1921, Vol. IX., No. 34, I pointed out how common it is for a papilloma to originate in a duct ampulla. Professor Hobday, F.R.C.V.S., informs me that in a cow's udder there is a sinus in the duct which corresponds in position to the ampulla of a human mammary duct and that in this sinus papillomata are also common. This fact supports the contention I adduced in my paper that papillomata are due to a local irritation that is applied directly to the epithelium and that they are not due to any cause acting outside the duct. I also made a special point of stating that the irritant might gain an entrance by means of the opening of the duct on the surface of the nipple, or it might be contained in the altered or unaltered secretions of the breast.

blocked by semi-organized thrombi (*Fig.* 216). In some the mammary ducts themselves appear filled with semi-organized tissue that completely blocks their lumens (*Fig.* 204). The tissue may be the result of hæmorrhage within the duct or an intra-elastica hyperplasia, I am not sure which, for no epithelial elements remain to give a hint as to the situation of this tissue.

PATHOLOGICAL CHANGES THAT RESEMBLE PAGET'S DISEASE OF THE NIPPLE.

There are two conditions which resemble in different ways Paget's disease of the nipple, but are totally different from it and from each other. The first has a microscopical and not a clinical resemblance. In the second condition the resemblance is clinical and not microscopical.

In the first, the cells of an underlying carcinoma have grown into the deeper epithelial cells of the surface epithelium of the nipple (*Fig.* 197). Usually in this condition the surface of the nipple is so puckered that it resembles a cluster of small warts. The nipple is fixed, retracted, and its surface is hard. The condition is much more common than is generally supposed, and is often mistaken for Paget's disease when examined microscopically. Clinically it does not in the least resemble it.

In the second condition, the surface epithelium of the nipple has been shed and the superficial underlying carcinoma has been exposed and resembles the clinical appearance of a typical Paget's disease of the nipple. Microscopical sections of this condition (*Figs.* 198 and 199) show that the underlying carcinoma of duct origin is exposed by shedding of the surface epithelium except at the margins where it is intact, and in no way resemble in appearance the changes that occur in Paget's disease. Clinically the condition does resemble it. The surface is red, dry, and may be covered with fine white scales. The edges are hard. The scales when examined microscopically do not show the concentric bodies included within epithelial cells which are generally supposed to be so typical of Paget's disease.

The practical result of this paper is to enforce the principle which is already accepted except by a few, that a breast suffering from Paget's disease of the nipple should be subjected to a most complete operation for its removal, together with the lymphatic glands in the axilla.

SUMMARY.

My conception of what is mainly occurring is as follows :—

1. Paget's disease of the nipple is carcinoma.

2. Carcinoma in the breast, with which Paget's disease of the nipple is usually associated, is a primary carcinoma of the breast epithelium.

3. The connection between (1) and (2) is that the agent of irritation which is inducing Paget's disease is also concerned in inducing primary carcinoma in the epithelial cells of the underlying breast, which is reached by means of the mammary ducts.

I have to thank many who have sent me material, often at great trouble to themselves. My gratitude is especially due to Mr. F. F. Burghard, Mr. Raymond Johnson, Mr. Percy Legg, Mr. Arthur Edmunds, Mr. Zachary Cope, Dr. Gilbert Charsley, and Mr. Harold Burrows. While writing this article I have been indebted to Sir Nestor Tirard for several suggestions upon the arrangement and presentation of my observations, and I have had the privilege of consulting Dr. Arthur Whitfield on many vital points.

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ARTHROPLASTY.

A Critical Summary of the Discussion upon this Subject, at a meeting of the Sixth Congress of the International Society of Surgery, held in London, on July 18, 1923.

By ALAN H. TODD, London.

The majority of the really epoch-making operations of surgery have passed through a certain number of phases in their life-history. Following upon their invention, and first description in surgical literature, they have endured a more or less strenuous experimental or evolutionary phase, during which they have been vigorously assailed by the exponents of older methods, and have had to struggle hard for their existence. Failures and partial failures result, at this stage, from imperfect technique and immature selection of cases, and unless the proposed operation has vigorous champions, or holds out particularly alluring prospects in the event of its developing into a success, there is a great danger of its being dropped at this stage and allowed to join that vast majority of "hopes blasted and things that might have been". A still greater danger, perhaps, is a sort of tidal wave of enthusiasm, in which the operation is adopted far and wide, performed indiscriminately by all sorts of surgeons in all sorts of cases (many of them unsuitable), and is finally drowned by the number of disappointing results that appear, and the saner judgements that prevail when the first wave of enthusiasm has passed. An operation, however, that is able to weather this storm is usually a good one, and its later history is less eventful; its uses become more clearly defined, its technique becomes improved, and the results that can be obtained by its employment come to be generally known and appreciated; it takes its place, in fact, in the science and art of surgery.

Arthroplasty is still passing through the period of 'storm and stress', though there was a general feeling of optimism concerning the operation amongst the large body of surgeons who crowded the Barnes Hall upon the occasion when the discussion was held. There could be no doubt, after hearing what was said, and seeing the results that were presented, that arthroplasty had come to stay, that it was a definite advance upon anything that had preceded it, in certain cases, and that it had a great future before it. But many of the speakers, and especially those who were its most enthusiastic supporters, were careful to emphasize that the operation was not one for the inexpert surgeon to attempt; that it was, and always must be, a method to be adopted only by those experienced in the surgery of bones and joints; that it was still in the experimental stage, though it had established itself as possessing a definite sphere of usefulness; that very much depended upon sound judgement and a wise technique; and lastly, that very much still remained to be done to define the indications and contra-indications for the operation, to extend and improve its field of usefulness, and to correlate its results.

Strictly speaking, the occasion was not so much a discussion as a presentation of a series of interim reports by a number of workers specially interested in this class of surgery. They served to show what had been achieved up to the present time, to define our present position with regard to arthroplasty, and to indicate the lines upon which future work ought to proceed. There is always a risk, at a large meeting of this kind, that the discussion may become abortive through being diffuse and ill-defined; but fortunately upon this occasion this danger was avoided, partly because the field for discussion is still fairly narrow (the majority of the operations having been performed upon the knee, elbow, and hip), and partly because Mr. Hey Groves, who introduced the subject, indicated the lines upon which discussion would be most profitable.

Arthroplasty was *defined* as an operative procedure upon an ankylosed joint having for its object the restoration of mobility, and several speakers attempted, somewhat unsuccessfully, to draw a sharp distinction between arthroplasty and excision. It was emphasized that stability as well as mobility must result from an arthroplasty, and that any operation which failed to satisfy these two conditions was unworthy the name of arthroplasty. MacAusland, in laying stress upon this point, quoted John B. Murphy's saying that "arthroplasty to be functional must be stable, and excision of joints results always in flail joints", and added, "A flail joint cannot be considered a proper result from a plastic operation. Excision has no place in the surgery of weight-bearing joints, save to obtain ankylosis, nor would it be used in non-weight-bearing joints if it were not that flail joints may be stabilized by means of light apparatus". The French speakers, and especially Santy and Leriche—representing the views of Ollier and his followers in Lyons—contended that in many cases the subcapsular excisions of Ollier gave results that were as good, functionally, as those of the typical arthroplasty, and it was unfortunate that so little attention was bestowed upon the very temperate and modest presentation of their results which these workers brought forward. Their summary was delivered in rapid French, and time was short, so that it failed to arouse the interest and discussion which were due it it; but one felt at the conclusion of the session that, whilst one side had undoubtedly set forth a very strong case, and had, indeed, upon some points, quite carried the day, yet there was much that was interesting and instructive that should have been heard upon the other side. Some account of their results, however, is presented below.

The *indications* for the operation were discussed from several points of view. It was generally agreed that sound bony ankylosis resulting from bygone pyæmia presented the most favourable field for operation as far as the bacteriology was concerned. MacAusland mentioned that streptococcus, pneumococcus, and gonococcus gave the most rapid ankyloses, with the result that arthroplasty could, as a rule, be performed earlier after these infections than after others. Poly-arthritic conditions, in which infection persisted in a smouldering condition year after year, were regarded as less favourable, and bony ankyloses were mentioned as being, in general, much more easily and satisfactorily treated by arthroplasty than were fibrous varieties. There was some difference of opinion as regards tuberculous cases, and some speakers

mentioned successful cases of arthroplasty after bygone tubercle. The consensus of opinion, however, was that in an ankylosis known to be due to the tubercle bacillus, arthroplasty was fraught with risk at any date, and was in consequence contra-indicated. Putti and MacAusland both expressed themselves as being definitely averse from operating in known tuberculous cases.

No definite time-limit was laid down after which arthroplasty could be properly undertaken; each case had to be considered upon its merits. It was recognized as a general principle that the longer the time-interval between the acute infection and the plastic operation, the greater would be the chances of success, and there appeared to be a widespread feeling that the risk of operating a year or two years after the initial acute infection was so small as to be justifiably taken. It was stated, also, and demonstrated by the patients, photographs, and statistics shown, that it was not necessary to wait until all residual infection of the soft parts around the joint had disappeared; indeed, it appeared from the histological evidence available that to do so would be to wait for ever. All that was necessary, in practice, was to wait a reasonable time until the clinical signs of infection had subsided, and attempts to provoke fresh exacerbations of infection by means of hot-air baths, massive doses of autogenous pyogenic vaccine, and the like, had failed. Elmslie made the admirable observation, at this stage, that the surgeon was confronted with two questions—namely, what to do and when to do it—of which the latter was the more difficult problem.

The condition of the soft parts has to be taken into account quite as much as that of the bones themselves; this was a point that was made by several speakers. In cases of ankylosis following war injuries, in particular, the associated destruction of skin, muscles, vessels, or nerves, might be so great as to render operation difficult or even impossible, whilst in other instances preliminary operations might be required, such as pedicled-flap grafting, in order to provide a satisfactory nutrition and covering for the proposed field of arthroplasty. Gross deformity, again, would call for operative correction in many cases before the arthroplasty itself was undertaken; for example, a hip ankylosed in flexion and adduction would demand preliminary correction, unless great difficulty was to be encountered at the chief operation.

Some difference of opinion was manifested, naturally, on the question of the surgical and anatomical conditions which justify the performance of an arthroplasty. Its more enthusiastic advocates would have performed the operation where others would have been conservative. The opinions of MacAusland, however, may be accepted as a fair summary of the views of those who are best qualified by their personal study of results to judge of this question. He says: "(1) Two stiff hips will indicate arthroplasty on one hip, or possibly both. (2) Two stiff elbows will present the same indication. (3) Two stiff knees will present a definite indication for an arthroplasty on one side at least. (4) Combinations of hips and knees in one individual—a condition not infrequently seen in multiple arthritis—is a very definite indication for attempting to mobilize one or more joints."

Putti, whose experience of arthroplasty is greater than that of any other one surgeon, laid especial stress upon the due consideration of the tempera-

mental and social aspects of every case. He, more than any other speaker, emphasized the need for complete and willing co-operation upon the part of the patient, the willingness to submit to a certain amount of pain in the early days of the convalescence, the painstaking after-treatment, and so on. He also laid stress upon the need for due consideration of the economic aspect of every case; the age and occupation of the patient were often determining factors, whilst it was futile to attempt an arthroplasty unless the patient possessed the time and the means to undergo the necessary after-treatment.

The occupational question is, of course, a relative and a labile one, and so it must always remain. At the meeting no decision was reached upon this point. As conditions of surgery change, the profession's verdict upon the operation must change also. For example, it has long been recognized and taught that a good strong bony ankylosis of the elbow, in good position, is preferable, in the case of a working man, to a more or less unstable excision. That is undoubtedly true. But that teaching does not negative the possibility of a thoroughly stable, useful, and reliable excision of the elbow, and cases of this kind are in existence and on record. It cannot be dogmatically laid down, therefore, that arthroplasty or excision should never be attempted in the case of a working man's ankylosed elbow; it can only be said that in a majority of cases at the present day the operation is not indicated. It is only by attempting these operations, however, that improvement will be attained, and as long as the development of the operation is left in the hands of able men, it will no doubt be brought much nearer perfection than it has yet attained, and many of the verdicts of to-day will need revision in due course. How much has already been achieved was obvious to all those present at the meeting who could recall the results that were available, say, ten years ago. The world owes a great debt of gratitude to those few courageous, determined men who have gone on developing the operation of arthroplasty in the face, sometimes, of great discouragement, until they have been able to place on record the remarkable successes that were revealed at the Congress of 1923.

If the occupational question is a variable one, at least the temperamental one is not. Unless the patient really needs the use of a movable joint, the operation should not be performed. The operation is a considerable one in the case of the larger joints, and one that involves an appreciable amount of shock, and of pain also in the early part of the convalescence, and unless the patient is prepared to undergo these for the sake of what he will gain, the success of the operation will be jeopardized. The after-treatment also is of the utmost importance; the patient must be willing and anxious to carry it all out patiently and assiduously, or else disappointment may ensue. For this reason, amongst others, arthroplasty is contra-indicated in most cases of rheumatoid arthritis; the patients are so often enfeebled, temperamentally as well as physically, by their prolonged sepsis and sufferings, that they will not endure the necessary post-operative régime; moreover, as Elmslie pointed out, the operation uniformly fails in this condition, owing to the reappearance of the disease in every new joint made.

On the other hand, it must be remembered that there are cases in which the presence of constant pain is one of the main indications for operative

treatment in chronic arthritis, if monarticular, and some form of arthroplasty is perfectly permissible, in well-selected cases, in preference to arthrodesis.

The discussion was introduced by Hey Groves, of Bristol, whose paper is given on page 234.

The next speaker was Putti, of Bologna, who dealt mainly with the technique of the operation of arthroplasty, which he illustrated by means of a long and very complete cinematographic record of an operation upon an ankylosed knee. Every stage of the operation was clearly shown, from the arrival of the patient in the operating-theatre, up to the application of the splint and his return to bed, where a weight-extension was applied. The steps of the operation need not be detailed here, for it was described in full in the BRITISH JOURNAL OF SURGERY, 1923, xi, 144, under the heading, "Surgical Clinics at Home and Abroad".

Following upon his demonstration of the operation, Professor Putti described and illustrated his after-treatment. He advises active movement of the 'knee' twelve days after operation, active and passive movements twenty-five days after operation, and a long course of hot-air baths. Massage and gymnastic and walking exercises follow in due course, and the cinematograph was again employed to show patients walking up and down slopes and stairs, walking and running on level ground, turning sharply round, jumping, and so on. Five patients were also demonstrated who had come from various parts of Italy especially for the meeting, and those present had an opportunity of seeing how well they could walk, how slight was their limp, and how stable were their neo-arthroses. All were cases of arthroplasty of the knee following military wounds, and several were the patients whose cases were recorded in the article in the BRITISH JOURNAL OF SURGERY referred to above.

Professor Putti's demonstration was exceedingly clear and masterly, and was without any question the outstanding feature of the discussion; it was a great personal triumph as well as a most lucid and convincing exposition of the matter in question. The conclusions at which this surgeon had arrived were based, he said, upon the experience of 142 arthroplasties.

MacAusland, of Boston, who followed, gave a detailed description of his technique as employed in arthroplasties of the elbow, knee, hip, jaw, and great-toe joint. The details were explained by the aid of a cinematograph film, and a large series of photographs and radiograms was also employed to demonstrate the condition of patients before and after operation. The technique resembled that used by Putti in its broad principles—namely, the free exposure of the joint, the division of the ankylosis as far as possible in the original line of the joint-cavity, the remodelling of the newly-cut surfaces in imitation of their original form, and the covering of them with a free transplant of fascia lata, followed by the complete suturing and closure of the wound. In the printed report of his speech which MacAusland had prepared for his audience, each of these operations was illustrated at every important stage by means of a photograph.

Leriche, of Lyons, spoke next, in French, and gave a short but very instructive paper by Santy, embodying the views of the Ollier school upon the subject of the mobilization of ankylosed joints. It was stated that arthroplasty, properly so called, had made so little headway in France, up

to the present time, that it was hardly possible to make a useful comparison between the results of that operation and those of the 'mobilizing resections' that had been described by Ollier in 1869, and had been extensively practised ever since. Arthroplasties, these authors said, had been carried out by them in so few examples that any comparison must be made by the standard of recorded cases, and not by those of their own operation-results. Under these circumstances, they felt that their best plan was to present a statement of the results they had achieved by Ollier's methods, and leave it to others to draw a comparison between them and those due to arthroplasty.

They laid great stress upon the fact that 'résections mobilisatrices', properly carried out in accordance with Ollier's instructions, were capable of producing a neo-arthrosis that was both mobile and stable. They insisted, moreover, that this was no new type of operation, but one that had been successfully performed for a number of years and that merited careful consideration in consequence. It was important that sufficient bone should be removed to allow of free play between the new articular surfaces, and they said that, whereas it was often stated that the main objection to resections was the risk of flail joint, the real risk was that of the recurrence of ankylosis, in consequence of insufficient removal of bone. (This, it may be observed, was taught many years ago in our own country by Sir Henry Howes.) Another point which they emphasized was the necessity of removing any portion of the joint-capsule or other structure that might be supposed to contain ossific structures—in other words, cells which, awakened to activity by the stimulus of the operation, might proceed to form bone, and so impair the functional result.

Santy then proceeded to record his views upon the comparative value of arthroplasty and mobilizing resection. In the case of the shoulder, he thought that operation of any kind was seldom required, owing to the excellent range of supplementary movement that was afforded by the mobility of the scapula. He considered, however, that there were two conditions in which operation was indicated, namely: (1) Ankylosis of the shoulder-joint in which the upper limb was fixed in a position of internal rotation, so that flexion of the elbow was rendered difficult or impossible; in such cases cervical osteotomy would correct the malposition, but excision of the shoulder-joint possessed the advantage of improving the movement of the joint proper at the same time. (2) Ankylosis of the shoulder complicated by fixation of the scapula to the chest-wall, a condition that is not infrequently found as a sequela of military wounds, and that lends itself to successful treatment, provided that the deltoid survives. Santy and Leriche, having studied the recorded results of arthroplasty of the shoulder, consider that a mobilizing resection, properly carried out, yields equally good results.

The elbow, they said, was a specially favourable site for the operation, and both the indications for the operation, and the details of its technique, had been completely worked out. They maintained that a well-executed resection would restore mobility, combined with stability, both to the elbow-joint and to the superior radio-ulnar joint. The special points in technique upon which they laid emphasis were: (1) The removal, on an average, of at least 5 cm. of bone, the section of the humerus being made across the widest part of the condyles, and that of the forearm being made at the level of the

neck of the radius, distal to the coronoid process. (2) The removal of the head of the radius is essential to the restoration of pronation and supination. (3) The ablation of every scrap of more or less ossified or ossifiable capsule, so as to remove all risk of post-operative bone-proliferation in this structure. (4) Careful conservation of the triceps. If there is any risk of impairing its power through lacerating its tendon during blunt dissection with the rugine, a temporary division of the olecranon process should be performed. (5) Finally, the post-operative treatment is of the utmost importance; complete rest in a plaster splint is the best method of guarding against the risk of activating any tendency to bone-proliferation in the residual structures of the joint.

At the wrist, they consider arthroplasty can rarely be required, but in those exceptional cases where some operation is indicated, excision gives an equally good result.

In the case of the hip, they think that operation is seldom necessary. In this joint, more than any other, it is absolutely imperative that an operation, if performed at all, shall result in stability as well as mobility. They maintain that where there is considerable destruction of bone, and consequent deformity, excision should be employed, whilst arthroplasty would be preferable in the remaining cases. (Tuberculous cases, however, form an exception, and the site of the bygone disease should not itself be attacked; some form of transcervical or subtrochanteric osteotomy should be preferred.) Santy pointed out, very properly, that in many cases where there has been a considerable destruction of bone resulting from the acute infection that produced the ankylosis, the distinction between arthroplasty and excision is almost a verbal one; a considerable amount of bone has to be cut away at the site of ankylosis in order to ensure mobility afterwards, and the anatomical condition left after the operation is tantamount to the result of an ordinary formal excision.

In the case of the knee, these surgeons freely agreed that arthroplasty had no equal.

Sir William Macewen agreed with the last speakers that flail joint was never the result of an excision of a joint, provided that the excision was intracapsular. He commented upon the use of fascia as a limiting membrane, analogous in its action to that of the bone-limiting periosteum, and said he thought that the somewhat imperfect range of movement shown in some of the cases demonstrated (photographically) by preceding speakers was due to insufficient removal of bone.

Elmslie, who followed, laid special emphasis upon the importance of relief of pain as one of the indications for arthroplasty, apart from any question of restoration of movement. He considered that in the case of the lower extremity, arthrodesis was preferable to arthroplasty, which was only indicated in examples of multiple ankyloses not due to rheumatoid arthritis. He had recently completed a survey of all the crippled children attending the special schools for the physically defective which are maintained by the London County Council, and had been very much impressed by the satisfactory functional results that were given by good arthrodeses in these cases. They were much better, and less troublesome, than those of arthroplasty.

One boy, for example, who had an ankylosis of the hip, could walk ten or twelve miles a day, and this was not an isolated instance. Incidentally, he mentioned that the radio-ulnar joint should not be attacked at the same time as the elbow-joint proper in an excision of the elbow.

Sir William de Courcy Wheeler, of Dublin, said that arthroplasty of the shoulder was no better than excision, provided that the deltoid was good and the scapula free. For working men, arthrodesis in good position was preferable. He described a successful case of arthroplasty of both knees, for ankylosis, and emphasized the importance of preventing pain during the after-treatment; pain resulted in spasm of the thigh muscles, and this, in turn, drew the newly-fashioned joint-surfaces strongly into contact, and led to atrophy of the fascial transplant and re-ankylosis. He thought the main point, in order that this pain might be avoided, was the free removal of the joint-capsule, because of the large number of sensory nerves contained in it. The work of Murphy and others had shown that capsule was very easily regenerated, and that there need be no hesitation in removing it freely.

Jurasz, of Prague, claimed that no arthroplasty would ever make a normal joint. He suggested that it was wiser to take the fascial transplant, in the case of arthroplasty of the knee, from the opposite leg, because the ilio-tibial band was an important factor in stabilizing the knee-joint, and as such ought not to be damaged on the side of the main operation. (It may be remarked that to take the transplant from the opposite limb is advantageous for another reason, namely, that with the tourniquet in place on the side of the ankylosis, there is often hardly enough room to enable one to cut a sufficiently large and strong transplant, and the thigh-incision is apt to encroach in consequence upon the area of the arthroplasty; if the flap is taken from the opposite limb, it can be cut of any desired size, and can be taken from the upper part of the thigh, where it is much stronger than it is further down.)

NOTE.—Since the above was written, the writer has received a letter from Dr. Leriche, in which he states the points that he would have made had he had time to present his own conclusions in addition to those of Dr. Santy, whose paper he read. He says that his experience consists of 15 subcapsular resections of the elbow by Ollier's method, 3 arthroplasties of the knee by Putti's method, and 2 resections of the hip. His opinion is that in the case of the elbow, arthroplasty, with the interpostion of a fascial flap, gives results which are no better than those of a good operation of the Ollier type. Movement, perhaps, is more easily restored after arthroplasty, but lateral stability is greater after the Ollier operation, and the ultimate range of movement is no less. He considers that arthroplasty is not an advance upon the older methods, except in the case of the lower extremity, but there the advance is 'immense'. After seeing Putti operate, and examining some of his patients, he thinks that his method of arthroplasty constitutes one of the most striking achievements of modern surgery, so much so that the time is coming when an ankylosis of the knee, in good position, will no longer be regarded as a sufficiently good result, and the surgeon will feel himself justified in seeking to improve upon it in selected cases.

SOME RESULTS OF NERVE ANASTOMOSIS.*

By Sir CHARLES BALLANCE, London.

I. PRELIMINARY REMARKS: LATERAL IMPLANTATION OF THE TWO ENDS OF A DIVIDED NERVE INTO A NEIGHBOURING UNINJURED NERVE.

In war, one of the reasons which militate against successful operation for injury of a peripheral nerve is the difficulty experienced in deciding by visual inspection the extent to which a nerve has been damaged beyond the obvious injury. Sepsis and concussion are the two factors which blind the eyes of the surgeon. War sepsis, as we all know, may destroy the nerve physiologically for a long distance. As well as this kind of damage, a high-velocity projectile passing through a limb, and severing an important nerve, possesses, besides its cutting action, an explosive influence which—though in the case of a modern bullet the wounds of entrance and exit heal by first intention, and there is no sepsis—leaves a part of the nerve dead above and below the site of division: its living cells are destroyed by the concussion. Moreover, the tendency of the operator to freshen the ends of the nerve by only cutting away a small piece of tissue from each end, especially when there is a difficulty in getting the two ends together for end-to-end anastomosis, is also a cause of failure to get the best result. If lateral implantation of the two ends into an uninjured near-by nerve can be shown to be successful, there will no longer be any need to be afraid of generous pruning of the ends of the divided nerve.

In experimental work, the finest iron-dyed arterial silk, with a fine straight needle (Van Horn), have been employed. The advice to pass the suture only through the perineurium, when dealing with tiny nerves, such as the descendens noni or recurrent laryngeal of a small monkey, is an unattainable counsel of perfection. In some cases the suture material itself is only a little smaller than the nerve to be sutured. The result appears the same wherever this fine suture and needle pass: union takes place. More than one suture is unnecessary; approximation of the divided ends of the nerve alone is required. Cargile membrane, being a dead tissue, has not been used. When the bed in which the point of suture lies is unsatisfactory, the nerve is wrapped round with a slip of muscle or a piece of living fascia. The ends of nerves should always be freshened with a sharp knife; a blunt knife or the use of scissors causes contusion beyond the line of section.

Many opportunities occur in war of treating cases in which portions of one

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* The patients and animals referred to in this paper were demonstrated to members of the International Society of Surgery on July 19, 1923, at the National Research Institute, Hampstead, by kind permission of the Medical Research Council, with the valued assistance of Dr. Dale. The researches on which the demonstration is based were made possible by a grant from, and the great facilities offered by, the Medical Research Council.

of the great nerves of a limb have been destroyed. No surgeon would perform any operation but an end-to-end anastomosis when this is by any means possible. What method, then, should the surgeon employ in his endeavour to restore nerve function when end-to-end anastomosis is impossible? The common plan in the past has been either to fashion a flap from the upper segment of the nerve, which can then be turned down to fill the gap; or to use some form of nerve-graft, either taken from another nerve of the patient (as for example the internal cutaneous or radial of the forearm), or a piece of human nerve preserved in alcohol or some other fluid; or to obtain a piece of living nerve from some other animal, and fix it in the gap between the upper and lower ends of the divided nerve. If a living human nerve is employed as an auto-transplant, some part of it will be absorbed, and some of the cells will live, just as happens when the auto-transplant, for other operation reasons, is of bone. Other grafts, of dead tissue, or of living tissue heterogenous to the tissues in which it is implanted, are absorbed completely, and remain only temporarily as a scaffolding for the invading neurilemma cells, whose function it is to bridge the gap. The graft, then, must be an auto-transplant if any part of it is to live; and no transplant can compare with the undamaged living portion of a nerve, between the two ends of another nerve, fixed to it by lateral implantation. It is of great interest to note that the length of nerve between the lateral implantations increases in size as function returns in the distal part of the limb. The microscopical appearances and conditions found after lateral implantation—and especially the nature and cause of the thickening of the nerve between the lateral implantations—will be reported on a subsequent occasion.

During the South African War twenty-five years ago I had several opportunities of treating cases in which lengthy portions of important peripheral nerves had been destroyed. A patriotic butcher, living not far from my house, was willing at any time to kill (without reward) a bullock or a sheep, so that I might remove the sciatic nerve, warm and living, from the animal, and employ it for bridging a wide gap between the ends of the divided nerve in a soldier. Over 6 inches of the great sciatic of a bullock was placed between the divided and widely separated ends of the great sciatic of a soldier; and the great sciatic of the sheep was used to fill gaps in smaller nerves such as the median and the ulnar. Thus all these cases were treated by heterogenous grafts, a method which, though giving in certain cases good results, belongs now to the history of the evolution of surgical practice in the treatment of peripheral-nerve injuries. The difficulty of treating a great sciatic nerve a large portion of which has been shot away must always be considerable, but the plan adopted by Mr. Joyce, of Reading (see a thoughtful paper by him in THE BRITISH JOURNAL OF SURGERY, 1919, vi, 418), was admirable. The gap in the great sciatic was bridged by three auto-transplants taken from the radial nerve of the forearm. Seeing the size of the great sciatic nerve, the only valid criticism is, why not six auto-transplants instead of three?

The following brief notes give the story of the early stages of recovery in a case in which the physiological continuity of the great sciatic nerve was entirely interrupted in the upper part of the thigh.

A man, age 24, suffered from severe hæmorrhage after tooth extraction. He was admitted to a hospital in London. An injection of a solution of calcium chloride was given in the lower part of the buttock. Subsequently it was found that the patient was totally paralysed below the site of injection.

SENSATION.—*Five months after the injection.* Sensation had returned to a point a little below the knee.

Eleven months and two weeks after the injection. Sensation (cotton-wool and pin pricks) had returned on the inner side of the leg to as far as just below the internal malleolus, but on the outer side sensation had not returned beyond a line three inches above the external malleolus. The sole of the foot, the dorsum, and the toes were without skin sensibility.

THE MUSCLES.—*Six months after the injection.* Some voluntary power in flexors of ankle.

Eleven months and two weeks after injection. Some atrophy of muscles of leg and foot. Strong voluntary flexion of ankle by calf muscles. Doubtful voluntary extension of ankle, but when the patient makes an effort of extension, the extensors in the upper part of the leg harden and patient says he feels a tingling down them as far as the toes. The toes are motionless. No voluntary movement of any of the intrinsic muscles of the foot. There is no response to the faradic current in the anterior group of muscles, in the peroneal group, or in any of the posterior tibial or calf muscles.

During the early part of January, 1921, while on an official visit to Cairo, I performed in each of three large monkeys a double lateral nerve implantation, with the assistance of my friend Mr. Dolbey, Surgeon to the Kasr-el-Aini Hospital. The details of the experiments are as follows :—

A. Black-faced Soudanese monkey.—The median nerve in the forearm was implanted in two places, 3 cm. apart, into the side of the ulnar nerve.

B. Black-faced Soudanese monkey.—The musculospiral nerve in the arm was implanted in two places, $6\frac{1}{2}$ cm. apart, into the side of the median.

C. Abyssinian trotting monkey.—The external popliteal nerve was implanted in two places, $3\frac{1}{2}$ cm. apart, into the side of the internal popliteal nerve.

In each operation the implanted nerve was fixed by two sutures to a longitudinal incision in the normal nerve. In these monkeys the nerves were large, and the operations were easy of accomplishment.

Professor Wilson, the professor of physiology, and Professor Derry, the professor of anatomy, kindly took much interest in these experiments. Professor Wilson wrote to me about two and a half months after the experiments had been done that " although there is still weakness and some wasting, there is almost complete recovery of motor power in the operated limb of all three monkeys."

Monkey A " has complete use of the hand and fingers, using, however, the sound hand by preference ".

Monkey B " has still indication of dropped wrist. The hand can be slightly extended and supination is possible. In walking, the hand is placed flat on the ground, and indeed the hand is slightly extended preparatory to touching the ground ".

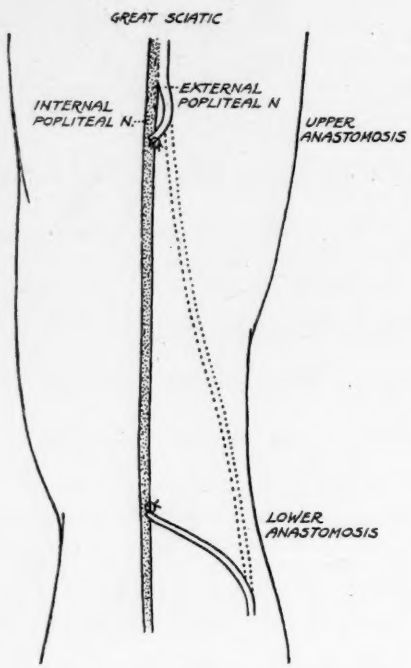

FIG. 221.—Double implantation of external popliteal nerve into internal popliteal.

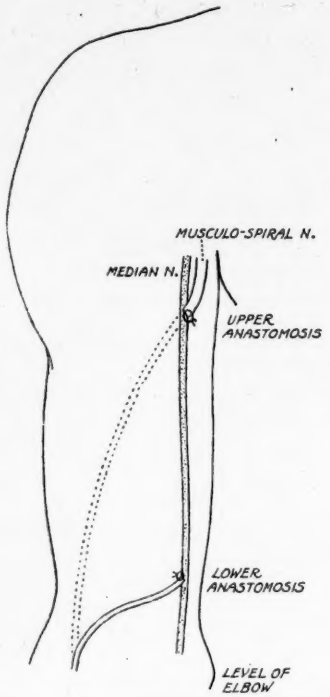

FIG. 222.—Double implantation of musculo-spiral nerve into median.

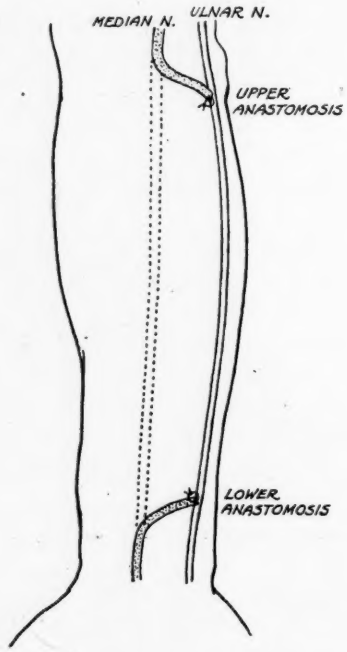

FIG. 223.—Double implantation of median nerve into ulnar.

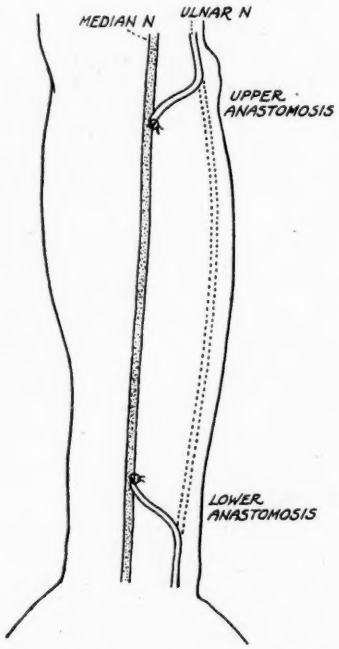

FIG. 224.—Double implantation of ulnar nerve into median.

Monkey C " runs about normally. Scratches itself with operated limb. There is active raising of the foot (true extension). The toes do extend, but at rest they are kept slightly flexed ".

Monkeys B and C lived for twenty months, and Mr. Dolbey told me that for many months before they died he was unable to observe any clinical evidence of weakness in the operated limbs. I hope some day to report with Mr. Dolbey more fully concerning these experiments.

During the great War I adopted the method of double lateral implantation in those patients in whom no other method was practicable. The operations performed (*Figs.* 221 to 224) were as follows :—

1. The external popliteal was implanted in two places into the internal popliteal.
2. The musculospiral was implanted in two places into the median.
3. The median in the forearm was implanted in two places into the ulnar.
4. The ulnar in the forearm was implanted in two places into the median.

I lost sight of most of these cases, as I was away from England for years, and each man was sent to England, usually not long after the operation had been performed. I have been told that in some cases the anastomosis was unwound by the surgeon in England under whose care they came, for one of the following reasons : (1) The operation was a failure ; (2) The nature of the operation was not appreciated ; or (3) The surgeon's mind was obsessed by the neurone theory, and he was unable to reconcile the cherished theory with the operation which had been performed.

For my part I hold that the views of Durante as expressed in Cornil and Ranvier* are a masterly exposition of the true pathology of the peripheral nerves. He writes : " The axis cylinder can no longer be regarded as a gigantic process from a cell making its way through ensheathing cells, an organ without any analogy in the economy, an element without any life of its own, existing only by virtue of its far distant central cell. The nerve tube appears to us as a chain of cells, in functional relation, but with individual life. Each interannular segment represents a single complete element, the segmental neuroblast, the protoplasm of which has secreted *in situ* the differentiated substances—the fatty substance myelin, and the axis-cylinder fibril. The axis cylinder is no longer an organ of central origin, but simply a fibrillar bundle differentiated within each segmental cell. Viewed thus, the nerve tube no longer forms a monstrosity, unique in the economy, but conforms to the general plan of the organism as a cellular colony, the elements of which react according to the same fundamental principles as do the cells of other tissues." Those who hold to the belief that a peripheral nerve is laid down as a chain of cells, and that within the protoplasm of each cell the myelin sheath and axis cylinder are developed, have no difficulty in understanding the wonderful success of the operation of double lateral implantation.

Case 1.—**Posterior cord of the brachial plexus implanted in two places into the side of the outer cord.**

Four weeks ago I saw for the first time since 1917, that is, *six* years ago, a soldier who was wounded in the left shoulder in an attack on the Turks on the

* " Nerfs " in *Manuel d'Histologie Pathologique*, 3rd ed., iii, 488.

Darian front at Salonika. The subclavian artery and brachial plexus had been wounded. When the patient was first seen the left arm was paralysed and a subclavian aneurysm occupied the lower part of the neck. Operation was necessary: the clavicle was divided and the artery above the aneurysm (subclavian) and that below (axillary) were ligated. The aneurysm was removed. It was then seen that the posterior or middle cord of the brachial plexus had been destroyed by the projectile for a considerable distance. The distal end of the proximal fragment of the posterior cord was implanted into the side of the outer cord of the plexus—that formed by the junction of the anterior primary divisions of the 5th and 6th cervical nerves; and the proximal end of the distal fragment was implanted, lower down, into the side of the outer cord, or perhaps into the commencement of the median nerve (*Fig.* 225). In this case there was no other possible operation but double lateral implantation of the ends of the damaged nerve. The condition of the limb a month ago was as follows: Arm, forearm, and hand much wasted; all muscles react to the faradic current, and all muscles react voluntarily with the exception of the extensor longus pollicis and the extensor longus digitorum. The patient had only had intermittent treatment, and Dr. Bailey, under whose care he has recently come, hopes that with proper and continuous treatment great improvement of the condition of the limb will take place.

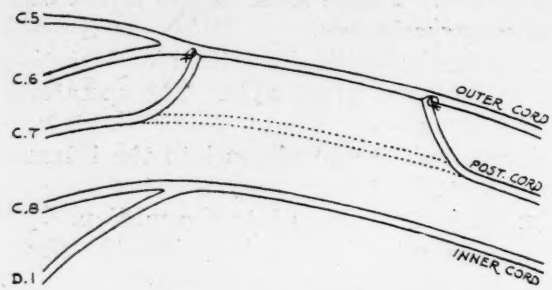

FIG. 225.—Double implantation of posterior cord of brachial plexus into outer cord.

Case 2.—**Median nerve in forearm implanted in two places, 5½ inches apart, into the side of the ulnar nerve.**

I operated on this soldier in September, 1917, at Malta. For all purposes he has a useful hand, but he does not employ it for writing because he has become accustomed to use the left hand for this purpose. The condition of the hand is in no small measure due to the fact that on returning to England he came under the care of Mr. Joyce at the Reading War Hospital. Thirty-four months after operation he was examined by the Committee on Nerve Injuries appointed by the Medical Research Council. They point out in their report that sensibility to pin-pricks was present over the terminal phalanges of the index and middle fingers, but that sensibility to cotton-wool was wholly absent. This last insensibility still remains at the ends of the index and middle fingers. The photographs show very clearly the success of the operation (*Figs.* 226–228). This man is at work.

Case 3.—**Ulnar nerve in forearm implanted in two places, 3½ inches apart, into the side of the median nerve.** (Mr. Joyce.)

This case was examined, two years after the operation, by the same Committee as examined *Case* 2. The man had a useful hand. No defect could be demonstrated in the functions of the median nerve, though it had been cut across one-third of its diameter in two places in order to effect the anastomosis. The muscles supplied by the ulnar responded to faradic stimulation, but it was doubtful if the abductor minimi digiti was voluntarily contracted. Pinpricks were appreciated within the whole ulnar region except over the terminal phalanx and ulnar border of the middle phalanx of the little finger.

Since this patient was reported on by the Committee of the Medical Research Council he has recovered voluntary power in the abductor minimi digiti and the abductor brevis pollicis. Faradic response can be obtained in all the ulnar intrinsics. The man is at work.

Both *Cases* 2 and 3, and *Case* 5, much interested the members of the Congress present at the demonstration.

FIGS. 226, 227, 228.—Photographs of the present condition of the forearm and hand in *Case* 2. The black lines in the forearms show approximately the operation performed: double lateral implantation of the median nerve into the ulnar nerve.

Case 4.—**End-to-end anastomosis of the ulnar nerve of a man, age 26 years, two inches above the wrist.**

The operation was performed fourteen months ago. and the case serves for the purpose of comparison with the operation of double lateral implantation. The nerve was divided in a wound made by a narrow chisel five weeks before the end-to-end anastomosis was done. Since the anastomosis the man has attended daily at St. Thomas's Hospital for massage and electrical treatment under Drs. Mennell and Levick, so that he has had the very best opportunity of early recovery. The wounds made by the chisel and at the operation both healed by first intention.

Four months after operation.—The ulnar muscles gave no response to faradism.

Six months after operation.—There was a faradic response in the 2nd palmar interosseus and in the abductor minimi digiti.

Seven months after operation.—Faradic response had returned in all the interossei except those of the 4th space. Sensation was perfect except at the tip of the little finger.

Ten months after operation.—Faradic response in all muscles of the hand supplied by the ulnar nerve. Voluntary response improving. Sensation normal.

Fourteen months after operation.—The muscles of the hand supplied by the ulnar nerve are still wasted, and though the hand is improving as compared with what it was like six months ago, yet it still retains the characteristic appearance of ulnar nerve palsy.

EXPERIMENTS.

Double lateral implantation. (Dr. Bailey's examinations.)

1. RHESUS MONKEY.—External popliteal attached in two places, ½ in. apart, to internal popliteal.

Five months after operation.—Faradic response in peronei muscles and in tibialis anticus. Flexors of ankle normal.

Seven months after operation.—Extensor communis digitorum and extensor hallucis respond to faradism. The toes extend in walking before the foot is placed on the ground, but at rest the toes are somewhat flexed. It should be remembered that splint treatment, so as to keep the extensors relaxed during the period of recovery, is not possible in the monkey. This monkey is no longer lame, and climbs about in the normal manner.

2. RHESUS MONKEY.—Median nerve of forearm attached in two places, 1½ in. apart, to the ulnar.

Five months after operation.—Faradic response is present in all muscles of hand supplied by median nerve.

Six months after operation.—The hand is being used in the normal way, except that when food is offered, the undamaged hand takes it.

3. RHESUS MONKEY.—Ulnar nerve of forearm attached in two places, 1⅛ in. apart, to median nerve.

Four months after operation.—Faradic response is present in all muscles of the hand supplied by the ulnar.

Five months after operation.—The hand is being used in the normal way, but when food is offered, the undamaged hand takes it.

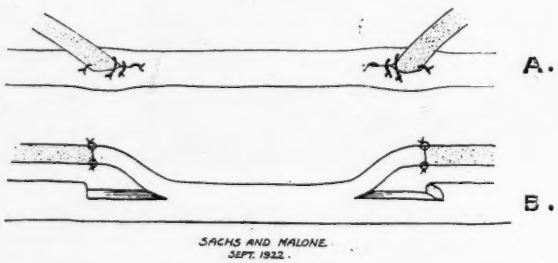

FIG. 229.—Double lateral implantation of a divided nerve into a neighbouring healthy nerve (*Sachs and Malone*). A, The method of choice. B, Method not recommended, as it does unnecessary damage to the healthy nerve.

An important experimental paper was published by Sachs and Malone in the *Archives of Surgery*, Chicago, in September, 1922, on double lateral implantation for bridging nerve defects.

In 1918 one of them, after removing a tumour of the ulnar nerve, found that there was such a large gap that it was impossible to get both ends together. He therefore implanted the central and peripheral ends into longitudinal slits in the median nerve. The result was a great success.

Dogs were used in all the experiments. The distance apart of the implanted ends varied from 1 to 6 cm. The implanted ends of the nerve were sutured to longitudinal incisions in the normal nerve. Complete recovery occurred in all the experiments. They were eighteen in number. In all, the

external popliteal nerve was grafted in two places into the internal popliteal nerve. Numerous other experiments are described. In one series flaps were cut from the intact nerve so that they could be united end-to-end with the two ends of the implanted nerve (*Fig.* 229 **B**). This method is not recommended, as it does unnecessary injury to the normal nerve. In another series an autotransplant of half the divided central end was fashioned to fill the gap in the nerve. This method, like the last method, is not recommended. Double lateral implantation gives the best results (*Fig.* 229 **A**); it is the simplest operation and the method of choice. The authors made numerous microscopic examinations. It appeared from these researches and from other tests that the fibres of the upper implanted portion of the external popliteal nerve became joined not only with fibres of the distal implanted external nerve, but also with fibres of the internal popliteal nerve.

Since the date of the demonstration Mr. Joyce has kindly sent me notes of five other cases in which he has performed the operation of double lateral implantation of the divided ends of the ulnar nerve into the median.

Case 5.—**Shell wound of left forearm, March 25, 1915. Complete division of ulnar nerve.** (*See* BRITISH JOURNAL OF SURGERY, 1919, vi, 427.)

Feb., 1916.—Admitted with advanced irreducible clawing of all fingers.

Operation.—Double lateral implantation of the two ends of ulnar nerve into median, 16 cm. apart. The patient went to Ireland.

Extract from letter from patient, Nov. 28, 1917.—" I have nearly all the feeling restored to my hand, the most sensitive being the little finger. It would be quite surprising to you to see how the hand has improved since your operation ".

Extract from letter from Sir Thomas Miles, Feb. 9, 1918.—" The man can close all his fingers and give a good grip. Power and sensation are improving ".

Case 6.—**Bullet wound of right forearm with injury to ulnar nerve, Nov. 12, 1917.**

Operation, Dec. 19, 1918.—Gap of 3½ in. dealt with by double lateral implantation of ulnar into median nerve.

Present condition, July, 1923.—Complete recovery of sensibility to pinprick in ulnar area. Faradic response in all ulnar intrinsics. Voluntary power in flexor brevis minimi digiti and abductor minimi digiti. Ulnar intrinsics still considerably wasted and hand clawed. Man working.

(This case was also shown by Mr. Joyce at the demonstration.)

Case 7.—**Gunshot wound of left forearm. Compound fracture of left radius and ulna, and injury to ulnar nerve, Aug. 27, 1918.**

Operation, Nov. 8, 1919.—Gap of 3½ in. in left ulnar nerve dealt with by double lateral implantation of ulnar into median nerve. Case transferred Edmonton, April 19, 1920, and not seen or heard of since.

Case 8.—**Shrapnel wound of left forearm, Sept. 18, 1918, with compound fracture of left ulna and division of left ulnar and median nerves.**

Operation, June 14, 1919.—Gap of 1 in. in median nerve: end-to-end suture. Gap of 4 in. in ulnar nerve bridged by double lateral implantation of ulnar into median nerve.

Last examination, March 19, 1920.—" Sensation returning in both median and ulnar areas. No faradic response in the intrinsic muscles of left hand. Good galvanic response to a small current."

Case 9.—**Gunshot wound in right forearm, Sept. 5, 1916, with division of ulnar nerve.**

Operation, March 21, 1917.—Gap of 4½ in. in ulnar nerve bridged by double lateral implantation of ulnar into median. Patient discharged from the army in August, 1917, and lost sight of.

II. THE EVOLUTION OF THE OPERATION FOR THE CURE OF FACIAL PALSY.

The first operation performed for the relief of facial palsy was in 1895. The operation selected was the suturing of the divided end of the facialis into the side of the spinalis part of the spinal accessory nerve (*Fig.* 230 A). In the following years the facialis was attached in various ways to the spinalis: (1) By making a flap of half the thickness of the spinalis and uniting it end-to-end with the facialis; (2) By completely dividing the spinalis and uniting it end-to-end with the facialis (*Fig.* 230 B); (3) By dividing the branch of the spinalis going either to the trapezius or sternomastoid muscles, and uniting the proximal end of the divided branch end-to-end to the facialis.

Meanwhile Barrago-Ciarella and Manasse carried out certain experiments on facio-spinalis and facio-vagus anastomosis on dogs, in which it was shown that recovery in the case of facio-spinalis anastomosis was complete in six months, and in the case of facio-vagus anastomosis in eight months.

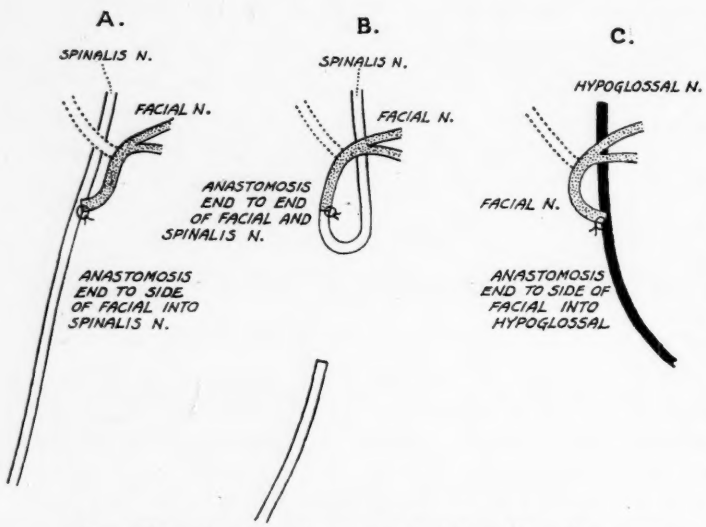

FIG. 230.—Anastomosis of the facialis with other nerves. A, Facio-spinalis anastomosis: end-to-side. B, Facio-spinalis anastomosis: end-to-end. C, Facio-hypoglossus anastomosis: end-to-side.

The results obtained in man, however, were not satisfactory, in spite of some brilliant exceptions. The interference with the spinalis was followed invariably with more or less deformity of the neck and shoulder, due to weakness or partial atrophy of the sternomastoid or trapezius or both. This is shown very clearly in a case by Kummer*, who performed the operation ascribed to Grant, of Denver. End-to-end anastomosis between the spinalis and facialis was done, and then, in order to obviate the atrophy following the division of the spinalis, the distal cut end of this nerve was united end-to-end with the proximal cut end of the descendens noni (*Fig.* 231). The

* *Schweizerische medizinische Wochenschrift*, 1919.

nerve-supply of the depressor muscles of the hyoid bone and larynx was sacrificed to energize the two great muscles supplied by the spinalis. The final result in the patient, a woman, was marred by atrophy of the trapezius. This is well shown in the figure illustrating Kummer's paper.

Further, associated movements of the side of the face and shoulder is always the first, and sometimes the permanent, result of facio-spinalis anastomosis. Dissociated movement of the face and shoulder is rare, requires a long patient period of re-education, and may never be regained even after years of effort. Again, symmetrical, subconscious, emotional movement of the two sides of the face, in which the cortical centres of opposite sides of the brain must co-operate in harmony — the movement which is most desired — is the one which most frequently eludes recovery.

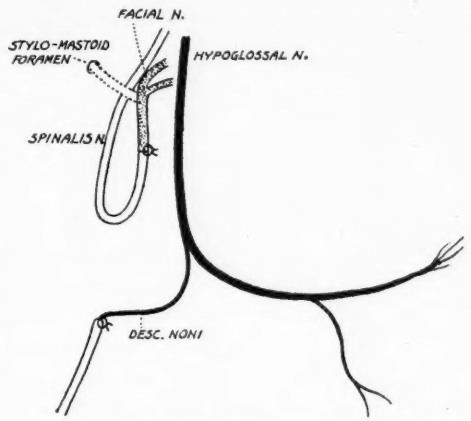

FIG. 231.—*Diagram of an operation (Grant, Kummer).* (1) Facio-spinalis anastomosis: end-to-end. (2) Descendens-noni-spinalis anastomosis: end-to-end.

The following case is of much interest in relation to this question: Three years after the occurrence of facial palsy due to fracture of the base of the skull, the cut end of the facialis was united to the side of the spinalis. Associated movements between the face and shoulder were first noticed five months later, and by the end of the year the whole face became much dissorted by any sudden movement of the thoulders. Ten years after the operation the patient was in Geneva; there was then no dissociated movement of face and shoulder. She consulted Professor Girard. Under local anæsthesia the trunk of the spinalis distal to the anastomosis was divided and immediately sutured. The patient was then asked voluntarily to move the angle of the mouth. She found she could do so, though this had never been possible before. Dissociated voluntary movement of the face from this time gradually improved, and three months later she could contract all the muscles of the affected side of the face powerfully by voluntary effort. The end-to-side anastomosis in this case was an attempt to cure the face and at the same time not to interfere with the muscles supplied by the spinalis. The attempt failed: the whole nervous energy flowing through the spinalis was required for recovery of the voluntary movement of the face. It is absolutely necessary to concentrate the attention on the main issue of the case, and let all subsidiary issues take care of themselves, in such a difficult problem as the cure of facial palsy. It has been well said, "On this earth of ours what great good has ever been, or can be gained, except by sacrifice? It is in every era, and in every zone, the law of life."

It is natural, then, that a search should be made for some other nerve which might give better results when anastomosed with the facialis than the spinalis. A distinguished physiologist suggested the glossopharyngeal nerve, but its smallness and relative inaccessibility did not commend the employment

of this nerve to the surgeon.* The vagus, too, in man, notwithstanding successful experimental results, is so important a nerve that its use for anastomosis with the facialis has not been attempted.

In 1901 the facialis was sutured to the side of the hypoglossus (*Fig.* 230 C), but one year later the result was only a partial success. It was gradually recognized that in order to win success it was futile to try to save the hypoglossus as well as to cure the facial palsy. In war and in surgery two main objectives are likely to end in failure. Thus it came to pass that the whole hypoglossus was divided, and united end-to-end with the facialis. This operation led to atrophy of one half of the tongue, and though this deformity of the tongue was of little moment, yet in 1906 a slip cut from the spinalis was brought across the neck and anastomosed to the distal cut end of the hypoglossus (*Fig.* 232). A few years later the divided descendens noni was united to the distal cut end of the hypoglossus (*Fig.* 233). In another case the divided gustatory nerve was united end-to-end with the distal cut end of the hypoglossus. Years afterwards all these patients were seen, and in each the tongue was protruded straight, and the side of the tongue which had been atrophied and paralyzed was of normal size and movement. The combined facio-hypoglossal and descendens-noni-hypoglossal operations give good results and can be recommended.

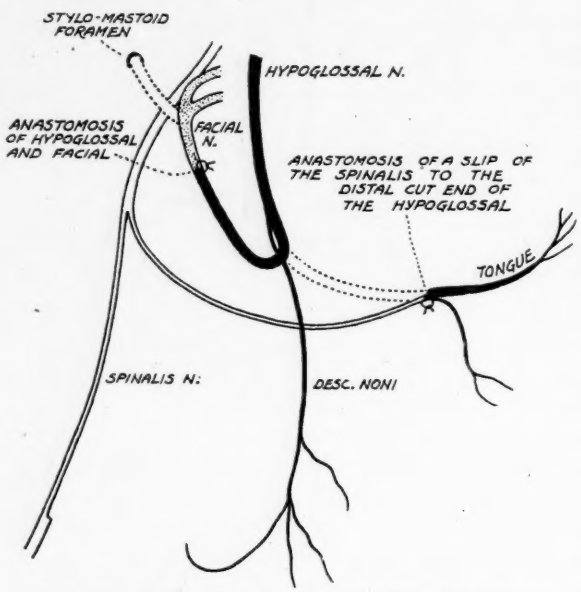

FIG. 232.—*Operation.* (1) Facio-hypoglossus anastomosis: end-to-end. (2) Spinalis (part of) and hypoglossus anastomosis: end-to-end.

A case of facial palsy in a woman, age 50, was treated by operation on Dec. 2, 1922. Complete facial palsy had been caused eight and a half months previously by acute suppuration. The notes illustrate the early signs of recovery. The anastomoses carried out were: (*a*) Facio-hypoglossus anastomosis, end-to-end; and (*b*) Descendens-noni-hypoglossus anastomosis, end-to-end. The trunk of the facialis where exposed looked red and unhealthy, and on stimulating the cut end no contraction occurred in any of the muscles of the face.

Six months after operation.—The asymmetry of the two sides of the face was less marked, and the palpebral fissure on the paralysed side was less wide. The tongue was protruded straight, and showed little sign of atrophy.

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* Facio-glossopharyngeal anastomosis has been done in the monkey, but too recently for a report to be made.

Seven months after operation.—The palpebral fissure was scarcely wider than on the healthy side.

Eight months after operation.—Slight voluntary contraction of the levator labii superioris was observed.

Eight months and three weeks after operation.—Definite voluntary movement of the levator labii superioris and the levator anguli oris was present, but only the lower half of the orbicularis palpebrarum reacted to the faradic current.

The following case illustrates the advantages, when nerve anastomosis has to be done, of youth and of early operation. Cases of facial palsy are left far too long under what is called medical treatment. A woman, age 21, was operated on for right mastoid suppuration in a country town. Complete facial palsy followed. It was found afterwards that the vertical part of the canal of Fallopius and its contents had been cut away.

Two months after the mastoid operation the nerves were anastomosed as in the preceding case, i.e., facio-hypoglossus anastomosis, end-to-end, and descendens-noni-hypoglossus anastomosis, end-to-end, were carried out. The trunk of the facialis looked white and healthy, and on stimulating the cut end contraction of all the muscles of the face occurred.

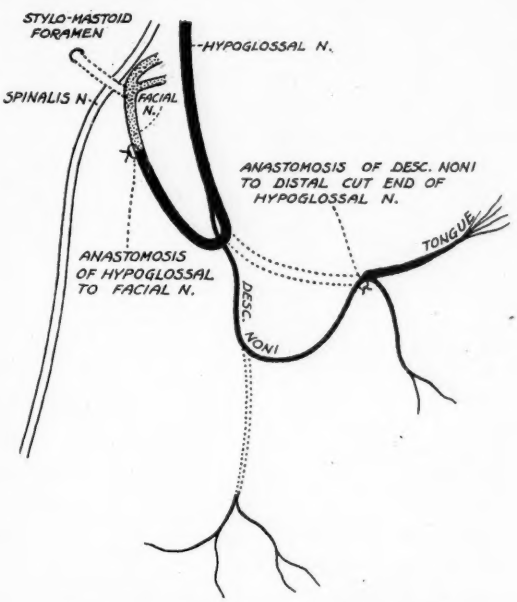

FIG. 233.—*Operation.* (1) Facio-hypoglossus anastomosis: end-to-end. (2) Descendens-noni-hypoglossus anastomosis: end-to-end.

Two months after operation.—The symmetry of the face at rest had much improved. The right eye, too, was not so widely open as before.

Three months after operation.—Slight voluntary movement of the angle of the mouth was present, as was also slight associated movement of the angle of the mouth when the tongue was moved backwards and forwards quickly.

Four months after operation.—Voluntary movement of the angle of the mouth much more definite. Tongue atrophy almost disappeared. No faradic response yet in the muscles except a slight one in the orbicularis palpebrarum.

Seven months after operation.—The two sides of the mouth move nearly equally in smiling. There is distinct voluntary movement in the frontalis. All muscles react to faradism, but the reaction is not so strong or quick as the normal. The tongue is protruded straight, and the right half is nearly equal in bulk to the other or normal half. Patient says she can taste on the right side of the tongue, but not so well as on the other side. She is quite sure of this, and says she had noticed for some weeks that the sensation of taste was returning on the right side of the tongue; but on testing no evidence of return of taste was found. The patient's statement may be correct: *just as voluntary movement may return in a muscle before the surgeon can detect any response to faradic stimulation.*

The suggestion to obtain recovery from lingual atrophy by passing the divided distal end of the hypoglossus through the hyoglossi and geniohyoglossi muscles and anastomosing it with the hypoglossus of the opposite side does not seem advisable. The more complete paralysis of the tongue produced by simultaneous interference with both hypoglossi would give rise to serious discomfort and inconvenience.

When the hypoglossus was first used for anastomosis with the facialis, it appeared theoretically to be superior to anastomosis of the facialis with the spinalis; for the representation of the movements of the shoulder on the cortex are far away from the representation of the movements of the face, while the representation of the movements of the tongue are in close proximity to the representation of the movements of the face and mouth; and, moreover, some facial fibres in the medulla are connected with the hypoglossal nucleus. Again, the hypoglossus in a healthy person is accustomed to work with the facialis for the purposes of mimetic expression. If associated movements are present they are slight, do not trouble the patient, and are not seen; whilst the associated movements of the shoulder and face which occur after facio-spinalis anastomosis are ugly and troublesome.

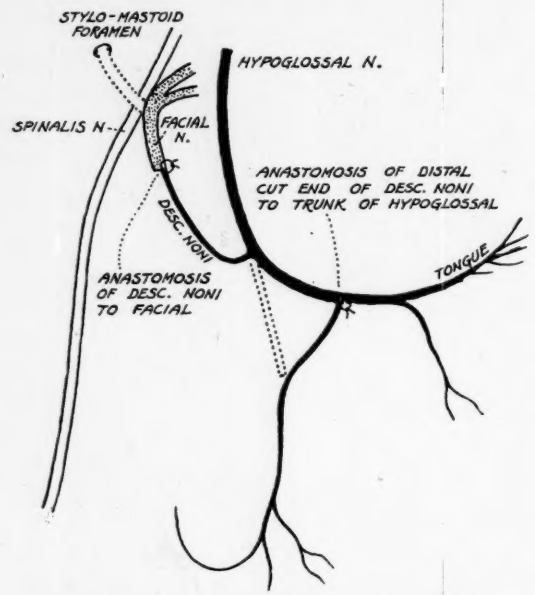

FIG. 234.—*Operation.* (1) Facio-descendens-noni anastomosis: end-to-end. (2) Descendens-noni-hypoglossus anastomosis: end-to-side.

The return of the sensation of taste on the side of the tongue after any of these anastomoses is truly a remarkable fact. Seven months after a facio-hypoglossal and a descendens-noni-hypoglossal anastomosis were performed, the patient declared that every week she noted an improvement in the power of tasting food on the side on which this sensation had been absent. Eight years after the divided lingual had been united end-to-end with the distal end of the hypoglossus, and twelve years after a facio-spinalis anastomosis had been performed, the sensation of taste, on suitable tests being made, was found to have completely returned on the side of the tongue.

A view of the descendens noni during an operation on the side of the neck of an adult, which seemed to be, but probably was not, unusually large, suggested a further stage in the evolution of the facial palsy operation. Was it possible to employ with success the descendens noni, and leave intact both the spinalis and the hypoglossus? The only way to elucidate this point was by experiment. In the monkey the descendens noni was divided, and sutured end-to-end to the divided facialis, and the distal cut end of the descendens noni was united end-to-side to the lower border of the hypoglossus (*Fig.* 234).

The latter anastomosis was done in order to avert permanent paralysis and atrophy of the depressor muscles of the hyoid bone and larynx. These operations were successful. In two and a half to three months (in various monkeys) from the date of the operations, faradic excitability had returned in all the muscles of the face, and in five and a half months no appearance of paralysis could be observed except that the animal preferred to place food (e.g., a greengage) in the pouch on the side of the mouth which had never been paralysed; but this had possibly become a habit. Three months after the operations in these monkeys, while they were being fed with apple, plum, or fig, a remarkable movement of the upper eyelid and pinna on the previously paralysed side was observed. It had before been noted that the palpebral fissure was no longer more widely open than on the normal side. After the larynx and hyoid have been drawn up with the pharynx in the act of deglutition, the depressor muscles come into action and return the hyoid and larynx to their normal position. On swallowing in these monkeys, when the depressor muscles contract, and perhaps also in consequence of movements or of fixation of the tongue, the upper eyelid was in intermittent movement, frequently closing over the eyeball, and further rapid to-and-fro movements of the pinna occurred, as if the retrahens auriculam muscle was in intermittent contraction.* In other words, there was clear evidence of an associated movement between the muscles supplied by the descendens noni and some of the muscles supplied by the facialis. The two anastomoses were functioning, and so far the experiments were successful.

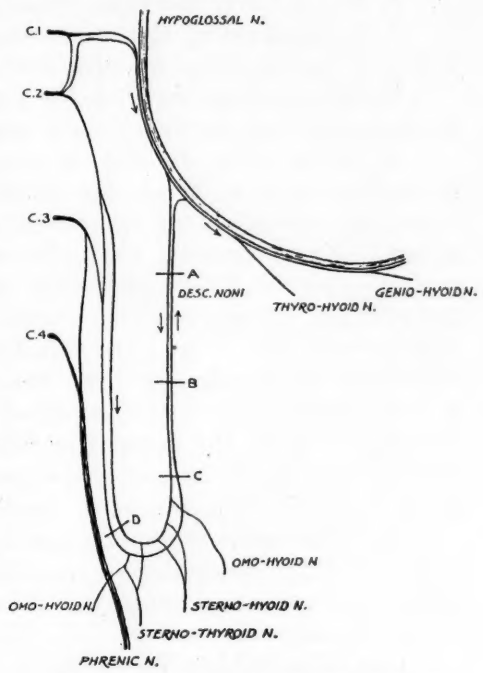

FIG. 235.—The spinal origins of the descendens noni and communicans noni (*after Testut*). A, B, C, D, Points on these nerves which were stimulated by Professor Kummer.

The descendens noni had been cut in the upper third of its course before any of its branches had been given off, and so by the anastomosis the whole of the nervous impulses which flow along it were transferred to the facialis. Professor Kummer† stimulated the descendens noni in dogs, and confirmed the results obtained by stimulating the descendens noni in man (*Fig.* 235). His conclusions are :—

1. The descendens noni and communicans noni convey motor impulses.

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* Monkeys were fed, and these movements were demonstrated to members of the Congress. The early recovery of the muscles around the eye in the monkey after descendens-noni-facialis anastomosis is quite different from what is observed in man after facio-spinalis or facio-hypoglossus anastomosis.

† *Revue Médicale de la Suisse Romande*, 1915, July.

The results obtained by stimulating different parts of the descendens noni vary, as motor impulses descend and ascend in this nerve.

2. In the upper third (*Fig.* 235, **A**) the usual effect of stimulation is depression of the larynx; but occasionally elevation of the larynx and contraction of half the tongue occur.

3. In the middle third (**B**) stimulation shows that the motor impulses both descend and ascend. Sometimes depression of the larynx is strong (*contraction forte*).

4. In the lower third (**C**) stimulation produces depression of the larynx.

5. Stimulation of the communicans at **D** causes contraction (*contraction faible*) of the depressor muscles.

It follows therefore that the right place to cut the descendens noni for anastomosis with the facialis is in the upper part of its course.

It seems very difficult of explanation that when an electric stimulus is applied at **A** or **B** on the descendens noni, sometimes depression, and sometimes elevation, of the larynx occurs. The muscles concerned in these antagonistic movements must, however, be very intimately connected, for, according to the Sherrington view of muscle action, when the depressors act the elevator will relax and vice versa. According to Kiebel and Mall (*Human Embryology*, 1910, vol. i) the infrahyoid muscles arise from a common mass of muscle which migrates down the neck and drags its nerve-supply with it. It is therefore possible that a motor filament to the thyrohyoid muscle might be dragged down the descendens noni, and then return again to travel along the hypoglossus till it reaches the spot where the other filaments to the thyrohyoid leave the hypoglossus to reach the muscle they supply.

The other more likely explanation appears to me to be this: The stimulus received by the descendens noni at **A** or **B** when elevation of the larynx takes place may actuate a sensory impulse whose motor reflex causes contraction of the thyrohyoid.

Can this problem be solved? Sir Charles Sherrington suggested to me that the descendens noni should be cut at **B**, and the proximal end stimulated. Presumably contraction of the thyrohyoid would take place. Then cut the hypoglossus proximal to the origin of the descendens noni and stimulate again. If contraction of the thyrohyoid occurs, it is due to a returning motor filament. If no contraction is observed, the stimulus was previously activating a sensory filament whose centre for reflex action has been now cut off.

As a further step it is proposed to reinforce the descendens noni nerve energy available for the recovery of the facialis by attaching also the proximal end of the divided communicans noni end-to-end to the facialis,* the communicans noni being divided before any muscular branches are given off, in order, as in the case of the descendens noni, to conserve all its nerve impulses for functioning the facialis. The distal cut end of the communicans could be sutured to one of the numerous nerves arising from the anterior primary division of the 3rd or 4th cervical nerve.

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* Since the date of the demonstration this operation has been done in the monkey. (*See Fig.* 236.)

It is curious that in the evolution of the operation for facial palsy the nerve first used for the anastomosis, and the nerves now suggested for the anastomosis, should all have an origin from the cervical spinal cord. The spinalis arises from the motor cells of the outer part of the anterior horn of

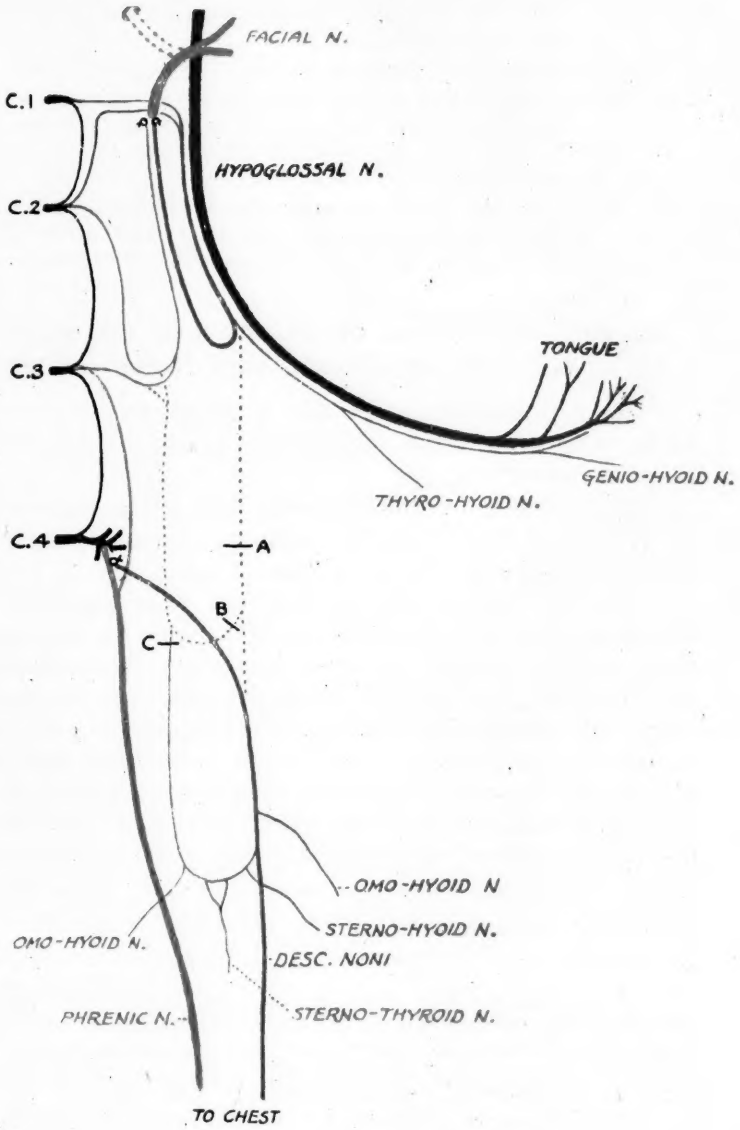

FIG. 236.—*Operation.* A, Site of section of descendens noni nerve. B and C, Sites of section of communicans noni nerve. The figure shows: (1) Descendens-noni-facialis anastomosis: end-to-end. (2) Descendens-noni-phrenicus anastomosis: end-to-side. (3) Communicans-noni-facialis anastomosis: end-to-end. (4) The distal cut end of the communicans noni was so minute that no attempt was made to suture it to another nerve.

The operation was done on a fairly large monkey. The descendens noni was relatively a large nerve which descended into the chest, while the communicans noni nerve was very small, and could only be followed with the aid of a magnifying glass. It will be noticed that the two nerves communicated rather high up, and that there was another 'ansa' lower down, from which the nerves to the depressor muscles of the larynx were given off.

grey matter of the spinal cord from the level of the 1st cervical nerve to as low as the 5th cervical nerve. The latest operation is a double anastomosis of the facialis—to the descendens noni, which arises from the 1st and 2nd cervical nerves, and to the communicans noni, which arises from the 2nd and 3rd cervical nerves.

EXPERIMENTS.

Facio-descendens-noni anastomosis in the monkey. (Dr. Bailey's examinations.)

1. BABOON.—
   Five months after operation all muscles of face respond to faradic current, with the exception of the occipitofrontalis. All deformity of the face has passed away.
2. SMALL RHESUS MONKEY.—
   Three and a half months after operation all muscles of the face respond to faradism except the orbicularis oris and the occipitofrontalis.
   Four months after operation all the muscles of the face react to faradism.
3. RHESUS MONKEY.—
   Four months after operation the orbicularis palpebrarum and the levator labii superioris react to faradism ; the others do not.
   Six months after operation the two sides of the face are quite symmetrical.

III. THE ANASTOMOSIS OF THE DIVIDED RECURRENT LARYNGEAL NERVE WITH THE DESCENDENS NONI NERVE OR WITH THE VAGUS.

Some years before the war I united the cut recurrent laryngeal nerve to the vagus ; but the patient disappeared, so the result of the anastomosis is not known.*

Dr. Frazier, of Philadelphia, told me a day or two ago that at the suggestion of Dr. Chevalier Jackson he had recently united the recurrent laryngeal nerve to the descendens noni.

The question of the value of the anastomosis of the divided recurrent laryngeal with another nerve could only be decided by experiment. In two goats and one monkey recurrent-laryngeal-vagus anastomosis was performed ; and in three monkeys recurrent-laryngeal-descendens-noni anastomosis was done. On cutting the recurrent laryngeal in each experiment, the distal cut end was stimulated. The vocal cord, which had been paralysed by the division of the nerve, was seen to abduct in a normal manner.

On examining the larynx with the bronchoscope in each of these animals at varying periods up to 200 days after the operation, no respiratory movement of the vocal cord was observed. But a change in the appearance of the vocal cord did take place. At first a typical cadaveric position was

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* *A.* COTTERILL.—*The Veterinarian*, 1893, June. Recurrent-laryngeal-vagus anastomosis was done in dogs and in a donkey. The idea was to determine whether roaring in horses could be cured by recurrent-laryngeal-vagus anastomosis. In dogs it is said that in six months the vocal cord which had been paralysed by the operation was working again, and in the donkey recovery of the cord took only three months.

B. MACDONALD.—*International Congress at Rome*, 1894. Reports that he united the recurrent laryngeal to the vagus in a horse. Roaring was produced and is said to have gradually passed off.

C. NAVRATIL.—*Arch. internat. de Laryngol., d'Otol. et de Rhinol.*, 1910. Described suture of the recurrent laryngeal nerve to the descendens noni in four dogs. The final functional result is not clear.

D. SHELTON HORSLEY.—*Ann. of Surg.*, 1910. Described the suture of the divided ends of the recurrent laryngeal nerve : the injury was caused by a bullet wound. The patient was a woman. Thirteen months after the operation " almost perfect motility of the previously paralysed vocal cord was observed ".

assumed, and the inner border was concave; but after from six to eight weeks from the date of operation the inner border of the immobile vocal cord became straight and tense.* There was, in fact, a tone about the paralysed cord which had not been present before. The change of tone about the vocal cord occurred in all the experiments—whether recurrent-laryngeal-vagus or recurrent-laryngeal-descendens-noni anastomosis had been done.

Fifty days after a descendens-noni-recurrent-laryngeal anastomosis (*Fig.* 237) had been performed in a monkey, the wound was opened, and the anastomosis was exposed. On stimulating (1) the hypoglossus proximal to the origin of the descendens noni, (2) the descendens noni, and (3) the site of anastomosis, the vocal cord was seen through the bronchoscope to abduct. This showed clearly that the anastomosis was, at any rate in part, functioning.

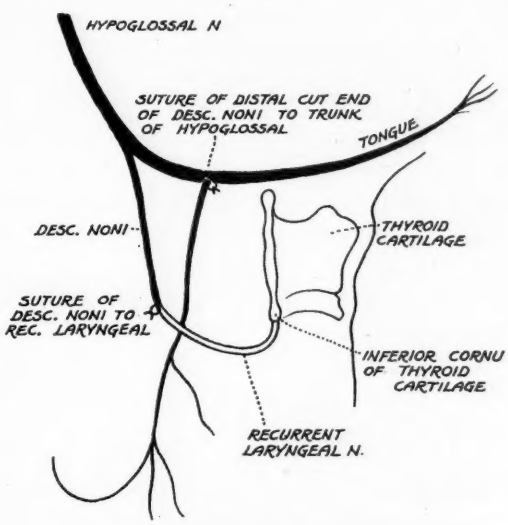
HYPOGLOSSAL N
SUTURE OF DISTAL CUT END OF DESC. NONI TO TRUNK OF HYPOGLOSSAL
TONGUE
DESC. NONI
THYROID CARTILAGE
SUTURE OF DESC. NONI TO REC. LARYNGEAL
INFERIOR CORNU OF THYROID CARTILAGE
RECURRENT LARYNGEAL N.

FIG. 237.—*Operation.* (1) Descendens-noni-recurrent-laryngeal anastomosis: end-to-end. (2) Descendens-noni-hypoglossus anastomosis: end-to-side.

From previous experiments it may be inferred that when these two anastomoses function, there will be at first *during swallowing* an associated movement of the muscles of the vocal cord with the elevator and depressor muscles of the larynx. The intermittent nervous energy flowing along the nerves distributed to these muscles during swallowing might possibly be a factor in the recovery of normal respiratory movement in the 'immobile' vocal cord.

Seven months after a recurrent-laryngeal-vagus anastomosis had been done in a monkey (*Fig.* 238), the wound was re-opened. The vagus was stimulated (1) proximal to the anastomosis, and (2) at the site of anastomosis. These stimulations caused abduction of the vocal cord: the excursions of the cord were not so wide as on the opposite or healthy side. Subsequently (? when the abductor was tired) strong adduction was observed. These observations were made not only by Mr. Colledge, but also by Dr. Gabriel Tucker, chief assistant to Dr. Chevalier Jackson. Previous to the stimulation it was also agreed that the immobile cord was straighter and exhibited more tone than a cadaveric cord. The conclusion is obvious: the anastomosis was, so far, a success.

After the operation for the cure of facial palsy, when the patient has recovered voluntary power over the muscles of the face, the associated emotional movements of the two sides of the face require a long period of re-education by voluntary effort before they are perfect. Voluntary abduction or other movement of the vocal cord is not possible. The movements of the vocal cord are subconscious acts. The harmonious subconscious

* The vocal cord in this condition was shown to members of the Congress.

movements of the two vocal cords, if such happens after anastomosis of the recurrent laryngeal to the vagus or the descendens noni, need not take longer, I think, to recover than the associated voluntary movements of the face after operation for facial palsy. The difference lies in the possibility of treatment. In the case of the face muscles, re-education of the associated movements of the two sides of the face is practicable by voluntary effort; but any such re-education is impossible in the case of the muscles controlling the movements of the vocal cords.

In discussing this question with Professor Starling, he suggested that if the animal was partially asphyxiated, the inspiratory effort would become so powerful that the muscles of the immobile vocal cord might receive sufficient nervous energy to contract. Professor Starling's suggestion was at once acted on.

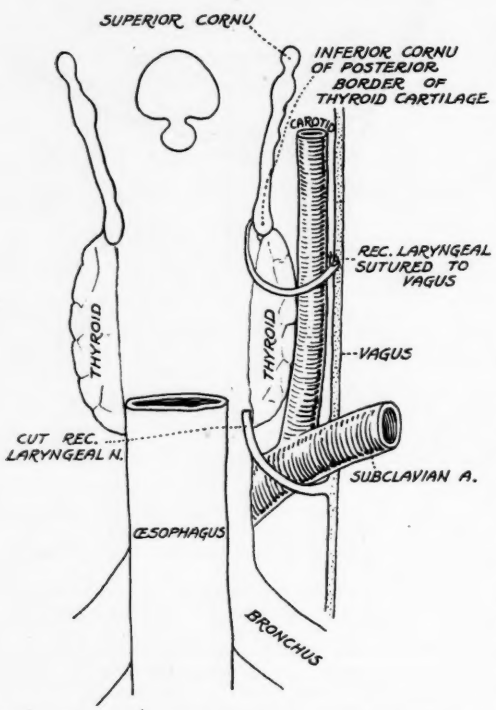

FIG. 238.—*Operation.* Recurrent-laryngeal-vagus anastomosis: end-to-side. (Viewed from behind.)

A monkey on which a descendens-noni-recurrent-laryngeal anastomosis had been performed four and a half months previously was placed under ether anæsthesia. The bronchoscope was inserted and gentle pressure made on the trachea. This induced strong adduction of *both* vocal cords. As soon as the pressure on the trachea, which had produced partial asphyxia, was relaxed, wide outward excursions of *both* vocal cords, equal on the two sides, were observed. These continued for about two minutes. The excursions of the previously immobile vocal cord gradually diminished in extent as the asphyxia passed off, and then ceased.

It is not feasible to repeat this experiment frequently in the monkey with the object of getting the immobile vocal cord to work naturally again. The experiment, however, possibly gives the key to the problem of the re-education in man of the vocal cord after anastomosing the recurrent laryngeal with another nerve.

In man, partial asphyxia can be readily and voluntarily induced by 'holding the breath'. 'Holding of the breath' is necessarily followed by a strong inspiratory effort, which would probably cause in man, as in the monkey experiment, abduction of the previously immobile vocal cord. By repeating the experiment daily for a considerable period of time, it seems not unlikely that a patient's immobile vocal cord might at last be re-educated to act in a harmonious, subconscious, normal respiratory movement with the vocal cord of the opposite or healthy side.

LEONTIASIS OSSEA.

By R. LAWFORD KNAGGS, London.

GENERAL OBSERVATIONS.

The expression 'leontiasis ossea' has been used to designate those cases of hyperostosis of the skull whose nature was not understood. Originally leontiasis was a descriptive term of great antiquity applied to cases of leprosy in which a rough, seamed, and thickened condition about the mouth suggested the muzzle of a lion. The appearance was produced by deposits of new material beneath the skin which gradually increased and coalesced until the entire face was changed into a hard mass with a deeply seamed and roughened surface, almost obliterating the features and sometimes closing the eyes (Starr).*

When Virchow suggested its use in cases of hyperostosis of the skull, he had in mind another form of 'leontiasis' in which masses of new connective tissue developed in the skin or in the subcutaneous tissue—a progressive hyperplasia of pre-existing connective tissue (fibroma molluscum—elephantiasis molluscum). He believed that the overgrowth of bone in hyperostosis corresponded exactly to elephantiasis of the soft parts, and he decided to call these cases leontiasis ossea, not because the bone disease produced a leonine appearance, but because he considered it to be analogous to a disease of the soft parts which did (Virchow, *Pathology of Tumours*, French translation, Arrhonsson, ii, 22).

Leontiasis ossea, if no longer a descriptive title, is at least a comprehensive one. But as the different forms of disease which it has hitherto included are gradually shown to possess a separate identity, they must of necessity be distinguished by more appropriate names. If the skull of Bickersteth's case, which is recorded by Murchison (*see Fig.* 245), be compared with the 'Bristol' skull described by Stack (*see Fig.* 246), a striking difference is at once apparent. The former is evidently the subject of a very extensive and exaggerated plastic periostitis, and in the latter the affection is one of the medulla—an osteitis. In the first the disease has advanced gradually and persistently; in the second it was probably diffused throughout the whole skull from the beginning.

These two skulls are examples of two different diseases. They are extreme instances, but there are many other cases of each form of disease in which only two or three bones, a single bone, or even a portion of one, are involved.

The majority of cases of leontiasis ossea fall naturally into two groups :—†

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* For plates see Leloir, *On Lepra.*

† A few recorded cases do not appear to fit readily into either of these categories, but these are for the most part clinical cases which do not appear to have come to a post-mortem and consequently have not been thoroughly worked out. (Starr, *Amer. Jour. Med. Sci.*, 1894, cviii, 680; Hale White, *Brit. Med. Jour.*, 1896, i, 1377). J. S. Collier (*Lancet*,

I. *Cases of very chronic periostitis, spreading slowly from bone to bone, to which the title of Creeping Periostitis of the Bones of the Face and Skull may be given.*

II. *Cases of Diffuse Osteitis of the Bones of the Face and Skull.* This may be (*a*) general, (*b*) circumscribed, or (*c*) local. The last, affecting the jaws, is usually due to dental sepsis or irritation. Probably these are all instances of osteitis fibrosa.

I. CREEPING PERIOSTITIS OF THE FACIAL AND CRANIAL BONES.

The periostitic form of leontiasis ossea has two distinctive features. It is remarkable for : (*a*) The great exuberance of the subperiosteal bony deposit, especially upon the facial bones; and (*b*) The slow relentless way in which the inflammatory process creeps from bone to bone until, after many years, almost the whole skull may be involved.

In the attempt to elucidate the nature of the disease, its characteristic features will be considered under the following heads :—

1. The origin of the disease in the nasal fossæ and its accessory sinuses.
2. The paths and method of its extension.
3. The changes in the nasal fossæ and accessory sinuses.
4. The complications.
5. The histology and morbid anatomy.
6. The pathogenesis.
7. Cases: historical, clinical, pathological.

1. The Origin of the Disease in the Nasal Fossæ and its Accessory Sinuses.—There can be no question that the disease begins in almost all cases in the nasal fossæ or the sinuses. In early cases the fossæ may be blocked with bone growth, and extension on to the face only just beginning.

The superior maxillæ, which enclose the fossæ, and whose cavities communicate with them, are the first bones to show visible enlargement, for the disease spreads in the first instance to their external surface when once it

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1901, i, 20) subsequently gave the termination of Hale White's case. The head of the patient had been noticed to enlarge after a fall from a window upon his head at the age of 4 years. At the post-mortem—following an operation—the skull was found to be thin, and the deformity to be due to a fold or pleat in the vault, no doubt resulting from the injury many years before. The posterior two-thirds of the vault had been telescoped on the base by pressure from above. The specimen is in the pathological department of the Queen Square Hospital for the Paralysed.

The work of Baumgarten (*La Leontiasis Ossea*, 1892) on this subject should be mentioned. I have been unable to obtain his monograph, but give the following extract from Starr's paper: "Baumgarten has made a careful study of this condition described by Virchow, and has collected descriptions of all these skulls in various museums of Europe. He has shown that some present a uniform thickening of all the bones, whilst others have shown an enlargement limited to the bones of the face, the cranium escaping. He points out that the latter class of skulls probably belonged to patients suffering from the disease acromegalia in which, as is well known, the bones of the face are very markedly enlarged. He considers that the pathological changes present are either a thickening of the surface of the bone alone or a change both in the surface and the diploë, the latter being transformed in some cases into a spongy tissue, in others into a hard substance like ivory. He admits that the literature does not contain any description of this disease during life, and does not think that cases have been observed."

emerges from the anterior nares. In some instances the disease is almost limited to these bones, and in advanced cases they show greater deformity than any others. Nor must it be overlooked that the antrum of Highmore and the teeth are two anatomical features well known to be predisposed to inflammatory troubles. The evidence of museum specimens, however, places the nasal fossæ and the sinuses under much greater suspicion than the teeth, and even in the worst cases the alveolar regions are often seen to have escaped altogether.

2. **The Paths and Method of the Extension of the Disease.**—The most probable cause of the periostitis is a micro-organism. The infection travels on the deep surface of the periosteum, and the inflammation which it sets up in that membrane is accompanied by an osteitis of the adjacent bony tissue.

As already stated, the inflammation begins in most cases in the nasal fossæ or one of the air sinuses, and after involving both fossæ it emerges in front and behind. On the face it spreads over the front of the maxillæ, often sparing the alveolar processes, and reaches the frontal bones along the frontal processes. Diffusing widely over that bone, it reaches the parietals, and then the occipital. Laterally it may spread to the malar bones or pass beneath them round the external surfaces of both upper jaws towards the pterygopalatine fossæ. Posteriorly it escapes by the sphenopalatine foramen into the pterygopalatine fossa, and advances thence in two directions. In one the stream of new periosteal bone passes round the posterior surface of the superior maxilla to merge with that already described as passing backwards below the malar bones; in the other it passes upon the great wing of the sphenoid into the temporal fossa and joins that covering the frontal bone.

The orbits are apt to be invaded from four points: (*a*) From the upper jaw over the inferior orbital margin; (*b*) From the frontal bone over the superior orbital margin; (*c*) From the pterygopalatine fossa by way of the sphenomaxillary fissure over either the superior maxilla or the sphenoid; and (*d*) Up the nasal duct.

The arch of the palate may be reached through the anterior and posterior palatine canals, and its posterior portion formed by the palate bone is often much less affected than the maxillary part.

It may appear difficult to explain the implication of the mandible by direct extension, but it probably takes place by way of the buccinator muscle and the pterygomandibular ligament, for it is the outer surface, close to the insertion of these structures, that is the first part to enlarge (*Case* 11.) Moreover, in *Case* 7 (Bickersteth's) the disease, having involved the whole of the ascending ramus, has travelled back to the skull, evidently along the temporomandibular joint ligaments, and attacked the mastoid region on the right side (*see Fig.* 245). The very unusual affection of the hyoid bone in this latter case must be similarly explained, the mylohyoid muscles probably constituting the bridge. The only instance in which dissemination by the blood-stream can be suspected occurred in the same case in the left fibula thirteen years after the commencement of the disease on the face.

The general plan of extension is very largely influenced by the attachments of the periosteum. Where that membrane dips between adjacent bone at the suture lines the inflammatory process is held up for some time. The

periostitic bony deposit accumulates and forms a heaped up, bulging, and sometimes almost overhanging edge. At last the attached periosteum is penetrated here and there by the infection, and invasion of the surface of the adjacent bone begins at two or three points. The power of other attached membranes, such as the temporal fascia or the palpebral ligament, to prevent for a time the coalescence of approaching streams of osseous lava is beautifully demonstrated in occasional cases (*Fig.* 241).

Sutures tend to become buried beneath the periostitic deposit when once the adjoining bone is attacked, but even in the late stages deep sulci in the osseous covering mark their situation. Nowhere are these facts more obvious than in the orbit, where bulging prominences contrast with smooth normal surfaces and all are exactly mapped out by the sutures (*Fig.* 241).

3. **The Changes in the Nasal Fossæ and Accessory Sinuses.**—A knowledge of the way in which the disease advances makes it possible to realize the process that goes on within the nasal fossæ where the mischief starts.

The infection probably penetrates the mucoperiosteal lining of one of the air sinuses, and after spreading beneath the periosteum around the cavity passes through its bony orifice and involves the corresponding nasal fossa. It must be understood that it spreads between the periosteum and the bone. When once the septum is reached no difficulty is likely to be experienced in its extension to the opposite side. From the fossæ the periostitis spreads into a variable number of the sinuses and leads to their gradual obliteration by periosteal deposits on their walls. Sometimes the remains of a sinus may be revealed in a section of the bone as a linear tract running to the natural exit (*Case* 12); in other cases the obliteration may be complete. The thickness of the new deposit of bone can sometimes be recognized.

The sinuses most often attacked are the maxillary antra, the frontal, and the sphenoidal; but the ethmoidal cells less commonly. Nearly always the corresponding sinuses on both sides are involved, and it may be very difficult to be sure in which one the disease started.

The obvious implication of one side of the face before the other, or a more advanced condition of disease on one side, is often seen, and indicates a unilateral origin. Only in one case (Sir Astley Cooper's, *Case* 3) has there been evidence of disease of a single sinus other than that just described.

The osseous deformations in the nasal fossæ themselves are usually extreme. The floor, the sides, the roof, the turbinate bones, and the septum all participate, and the fossæ, when viewed from the anterior or posterior apertures, appear blocked by bony masses which fit together like parts of a jig-saw puzzle. The vomer may be nearly an inch in width and the turbinate bones changed into sessile bosses. The identity of the inferior may sometimes be proved by a dimple on its under surface marking the opening of the nasal duct, whilst that canal is apparently obliterated in its length.

4. **The Complications.**—It is quite certain that one of the earliest signs must be nasal obstruction. It will usually be present to some extent before any deformity is recognized. The deformity, however, seems to have absorbed the general attention, and nasal obstruction is only occasionally alluded to in the clinical accounts (*Cases* 2 and 8).

Trouble with the lachrymal apparatus from stenosis or obliteration of the

nasal duct is also to be expected. It is occasionally mentioned, and because it occurred before any deformity appeared it has in two cases been looked upon as the exciting cause of the disease (*Cases* 2 and 5).

A remarkable condition of the left frontal sinus is presented in the macerated specimen of Sir Astley Cooper's case (*Case* 3). The walls of the sinus have enlarged towards the centre in three rounded masses, leaving the cavity represented by a triradiate cleft. The mucous lining must have been constricted in the middle and an hour-glass shape given to its interior. The two lateral globular portions have evidently become distended. The lower one has eroded by its pressure the orbital roof, and the upper one has raised up the floor of the anterior fossa of the skull and also eroded it. This has produced a circular chimney half an inch high, three-quarters of an inch in diameter, and open at the top. Its wall is formed by the abrupt rearing up of the thin compact tissue of the fossa. Through this chimney the osseous arrangement in the interior can be examined. There is no evidence of suppuration, and it is probable that the condition was caused by an interference with the drainage of the cavity—that it was a consequence of the disease and not an exciting cause (St. Thomas's Hosp. Museum, No. 610.)

That the eyes must suffer is clear. Proptosis and exophthalmos are frequently mentioned, and blindness is often present in the late stages. This may result from corneal ulceration and perforation (*Case* 5), from compression by bony outgrowths, or from traumatic rupture of the exposed globe (*Case* 5); but the stretching of the optic nerves, or pressure upon them in their course, may result in optic atrophy and failing vision.

The occurrence of mental or cerebral disturbance in these cases would not be astonishing in view of the great vascularity of the diseased bones in close relation to the anterior lobes. Some signs of these are met with in the sparse clinical records. Thus the pugilist (*Case* 5) had occasional symptoms of insanity in the last two years, and died from an effusion of blood beneath the cerebral arachnoid. Young's case (*Case* 9) was three times in an asylum, but not until after the swellings appeared. He had hallucinations of sight and hearing, and died of syncope during exertion in connection with one of them. There was in this case a family taint, for one sister died in a lunatic asylum.

A girl 6 years old came under my observation at the very beginning of the maxillary hyperostosis. When 11 she began to have 'fits' of an uncertain nature, and a skiagram showed that the anterior part of the base was affected as well as the frontal bone and mandible. She died at the age of 25 in the Leeds Union Infirmary, where " her fits became more frequent and severe, and her mental condition, never very bright, gradually deteriorated ".

Bickersteth's case (*Case* 7) died of coma without any very evident cause, and Astley Cooper's patient, whose frontal sinus has just been described, was seized with a fit which seemed to be of an apoplectic nature, and died almost immediately in St. Thomas's Hospital.

Suppuration and necrosis is an extremely rare complication, and is no doubt due to a secondary infection; *Case* 13 is an instance.

5. **Histology and Morbid Anatomy.**—When the enlarged bones are sawn across they are found to be composed of a closely cancellous bone which extends

through both the original bone and the periostitic deposit. There is no outer layer of compact tissue, but the summits of botryoidal protuberances may be slightly polished, and the surface is perforated by innumerable apertures for small vessels. The original bone has been involved in a secondary extension of the superficial inflammation, so that its limits can seldom be detected, and then only vaguely. In the lower jaw of the Peruvian's skull (*Case* 4) traces of the original compact tissue are to be seen on the face of a sagittal section, buried in a mass of new bone. The character of the bone in these cases was investigated by a Committee of the Pathological Society appointed to report on Bickersteth's specimens (*Case* 7).

The tumour on the fibula was carefully examined. "The great mass of the tumour was made up of dense, ivory-like bone, with here and there an extremely delicate cancellous structure. . . . The dense bone was very tough and to the naked eye appeared compact at first view, but on closer examination was seen to be studded with numerous minute openings. The microscopic appearances were peculiar. The compact tissue was traversed in every direction by large branching and communicating vascular channels forming in some cases a close network. At the point of confluence of these canals there was often a sort of ampulla. From the sides of the larger canals finer ones were given off which formed communications with those coming off from the neighbouring, or even from distant, large ones. . . . The spaces between the canals were filled up by bone tissue of ordinary character. There was an indistinct lamination for the most part parallel to the walls of the canals. . . . The lacunæ were in general very numerous, but they were small and for the most part elongated. The majority were furnished with very delicate canaliculi. . . . Very few traces of Haversian systems were to be seen. . . . The cancellated bone presented for the most part the ordinary characters, but even here were found many of the large canals running into the cancelli". The composition of the bone was practically normal.

The Committee also examined a section from the Peruvian's lower jaw (*Case* 4). This presented characters identical with those observed in the fibular tumour. They concluded that "the structure of the cranial bones in that case (*Case* 7) was the same as the fibula", but they did not examine them for fear of injuring the specimen. An illustration of the microscopic appearance was given with the report (*Trans. Pathol. Soc. Lond.*, xvii, 250, plate 12).

6. **Pathogenesis of Creeping Periostitis.**—There is no bacteriological proof that creeping periostitis is due to micro-organisms; but no recorded observations on this point have been found. The suggestion that it is of micro-organic origin is based upon the curious way in which the disease spreads, which can only be explained by a living infection. Its nasal origin, too, lends the idea some support. The infection must clearly be one of low virulence and capable of long duration, and it does not cause suppuration. The infection responsible for serous periostitis and serous osteitis in the long bones has these characters, and in those cases in which it causes "necrosis of the compact tissue without suppuration" it is possible to trace another resemblance in its slow progressive extension beneath the periosteum.

There is good reason to believe that the organism in serous periostitis is a staphylococcus of attenuated virulence, and in the absence of any definite

micro-organic findings in creeping periostitis, it is perhaps permissible to point out these similarities, though great differences are only too obvious.

But how is the profuse deposit of periosteal bone which characterizes the creeping affection of the skull bones to be explained? In the only case in which a long bone was affected, the same or even a greater exaggeration of new bone formation was observed. Are we to suppose that this is the way in which a hitherto unrecognized organism manifests its presence, or can we look upon it as due to some peculiar idiosyncrasy on the part of the bone-forming tissues of occasional individuals resulting in this unusual response to an infection which is not unfamiliar to us? These questions cannot be answered yet.

7. **Cases: Historical, Clinical, Pathological.**—*Case* 1.—MALPIGHI. The first reference to this disease is found in the *Opera Posthuma* of Malpighi (1700 A.D.). One of his observations (p. 68) describes a skull in the treasury (collection ?) of the Most Serene Duke of Mutina. It weighed 10 Bononian (Bologna) pounds, i.e., 120 oz., and was without the lower jaw. The description, in Latin, is quaint and somewhat difficult to follow, but it is quite clear that the specimen was an example of the periostitic form of leontiasis ossea producing marked deformity of the upper jaw, orbits, and cranial bones; a single old tooth was deeply fixed in its alveolus, and the disease had spread to the first cervical vertebra.

FIG. 239.—Fourcade's case. View of the complete skull. (*After Lebert.*)
For the two photographs of this case I am indebted to Mr. H. E. Powell.

Case 2. — FOURCADE'S. This is the first case with a clinical history. An account of it is given by Virchow. Fourcade was a surgeon at Perpignan and had a son, who except for an attack of variola had enjoyed good health till he was 12 years of age (1734).

At this time his father opened for him near the inner canthus of the right eye a lachrymal tumour which suppurated for a very long time. There developed at the same time on the nasal apophysis of the right superior maxilla a tumour as big as an almond, which grew till at the age of 15 it compressed the nasal cartilage in such a manner as to prevent the youth from breathing except by the mouth. The disease then extended to the inferior maxilla,

which kept its normal form only at the articular extremities and alveolar borders. The superior maxillæ, the walls of the orbits with the exception of the roofs, the nasal openings, the palate and malar bones were invaded and enlarged till they formed shapeless masses. At 20 years of age the face was monstrous. He had exophthalmos with myopia, difficulty in speaking, and general enfeeblement.

He died, blind and phthisical, at the age of 45. The macerated head weighed 8 lb. 4 oz.; the inferior maxilla alone 3 lb. 3 oz. (*Figs.* 239, 240). Great tuberous and lobulated exostoses having the density of marble protruded from the lower jaw and inferior borders of the orbits: the cranial bones were thickened, with little, smooth, and completely sclerosed excrescences. The frontal and maxillary sinuses had entirely disappeared. The rest of the skeleton was remarkable for the fragility of the bones (VIRCHOW, *Pathology of Tumours.* French trans., Arrohnsson, ii, 20. LEBERT, *Traité d'Anat. Pathol.*, plates 32 and 33).

FIG. 240.—Fourcade's case. The lower jaw from above. The grooves for the facial arteries are very conspicuous. (*After Lebert.*)

Case 3.—SIR ASTLEY COOPER'S. Specimen in St. Thomas's Hospital Museum, No. 610.

The upper jaws are the chief seat of the mischief. Rounded bosses project forward 1½ to 2 in. from the anterior surface of each bone, above the unaffected alveolar processes. Different sections made through the specimen show each antrum to be obliterated by the growth, which encroaches also on the nasal fossæ. The frontal and ethmoidal sinuses are similarly obliterated. The very unusual condition presented by the left frontal sinus has already been described on page 351. The nose is difficult to examine, and the condition of the posterior part of the fossæ does not appear to be so exaggerated as in many cases. The specimen was taken from a Billingsgate fishwoman long remarkable for her hideous appearance. Two large swellings had grown under the orbits in the forepart of the cheeks, between which the nose appeared wedged and the nostrils closed. Each eye projected considerably from its socket. The lower jaw was not affected. The manner of her death is described above (page 351). (COOPER and TRAVERS, *Surgical Essays*, Part 1, 171.)

Case 4.—The skull of a Peruvian in the R.C.S. Museum, No. 1358, Gen. Path. Sect., is evidently an old one. It has often been referred to by writers on leontiasis. There is no known history attached to it, but it is a very

FIG. 241.—The Peruvian skull—no history (R.C.S. Museum, No. 1358.1, Gen. Path. Sect.). The illustration shows how the attachments of the periosteum to the sutures, and of the temporal fascia to the temporal ridge, have limited temporarily the extension of the periostitis. In the orbit the different bosses are exactly limited to the surfaces of various bones forming that cavity. The right ascending ramus of the mandible is seen to be severely affected.

FIG. 242.—Antero-lateral view of the pugilist's skull, Howship's case (R.C.S. Museum. No. 1357.1, Gen. Path. Sect.). The intra-orbital boss and the large facial tumour arise from the maxilla. The groove between them shows the influence of the palpebral ligament and the suture between the maxilla and malar bone. The malar bone is only slightly involved, but the osseous stream passes below it to the posterior surface of the maxilla.

instructive specimen, because the peculiarities of the extension of the disease can be so easily studied upon it. (*Fig.* 241.)

Case 5.—Pugilist's skull in R.C.S. Museum, No. 1357.1, Gen. Path. Sect.

This is another example of immense rounded bosses jutting forward from the front of the superior maxillæ (*Fig.* 242). The posterior nares show solid turbinate bones fitting into a much swollen septum. The sphenoidal sinuses are filled up with bone and the frontal sinuses are obliterated (*Fig.* 243). The conditions are more advanced on the left side. Both the orbits are practically filled up with exostoses. The specimen is described in Sir James

FIG. 243.—Posterior view of the specimen from Howship's case. A coronal section has passed through the sphenoidal sinuses. It shows the effect of the disease on the nasal fossæ and the sphenoidal sinuses; the osseous growth fills the pterygomaxillary fossæ, extending into the orbit, and blending below the malar bone with the facial mass. (A) Left orbit opened up showing bone outgrowth within. (B) Obliterated sphenoidal sinuses. (C C) Malar bones—temporal processes. (D) Left inferior turbinate bone. (E) Pterygoid fossa. (F) Left middle turbinate bone. (G G) Right and left hamular processes. (H) Vomer. (I) Right inferior turbinate bone. The shadow above and to its left suggests a cavity. The shadow, however, is part of the vomer, which leaves only a chink to represent the right nasal fossa. (J J) Teeth. The hard palate, between, looking down and backwards. (K) Bony mass protruding from pterygomaxillary fossa, passing up into the orbit and down beneath the malar bone to coalesce with the outgrowth on the face.

Paget's *Lectures on Surgical Pathology* (4th ed., 535). In spite of some discrepancies there can be no doubt that it is derived from a living case described by Howship (*Observations in Surgery*, 1816, Case 9, p. 26, with portrait—*Fig.* 244). Le Dentu, in referring to Howship's case, gives the same catalogue number as Paget. The clinical history is interesting.

The subject was a man about 60 years of age who believed the disease began eighteen years before death in consequence of repeated blows received in the face through fighting. The first symptom was the very sudden onset

of inflammation in both eyes which evidently ended in double lachrymal abscess. This occurred fourteen years before Howship saw him in 1811. After some months, osseous swellings formed below each orbit. Later one eye suppurated, its cornea sloughed, and it shrivelled; and the other, when it was protruded and lying upon the hard tumour in the cheek, was struck by part of an iron bedstead he was handling, and burst.

In 1815 the patient was in good health. The tumours were not tender on pressure. They appeared to occupy the whole space of each orbit, as well as the cavities of the nostrils, which were almost obliterated. There were varicose veins in the skin covering the swellings. The history of occasional insanity and the cause of death have been given above (page 351).

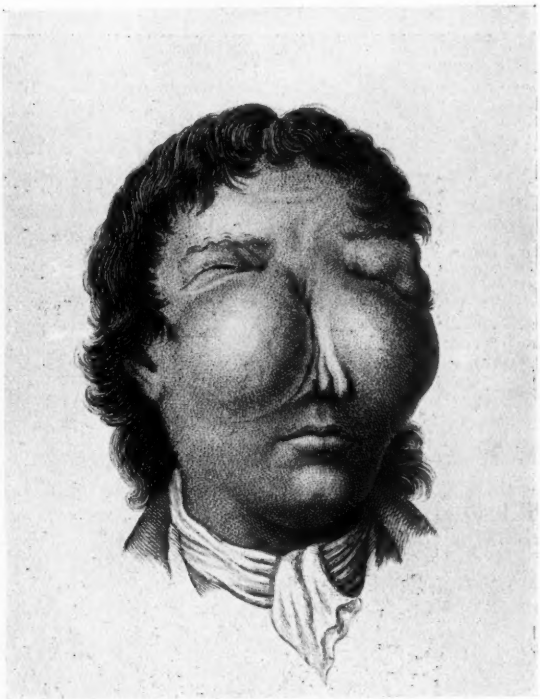

FIG. 244.—Portrait of the patient in *Case* 5. (*After Howship.*)

Case 6.—A specimen (No. 397, St. Bart.'s Hosp. Museum, old No. 1.62) quoted by Paget in his *Lectures*.

The superior maxillæ are not much enlarged or deformed on the facial aspect, but the nasal septum and lateral walls are much thickened, and the antra with the frontal and sphenoidal sinuses are greatly diminished or almost occluded. The specimen is of interest because it shows early invasion of the anterior surfaces from the nasal fossæ, and from the orbits through the infra-orbital canals—a patch of periosteal deposit being present below each foramen. A similar invasion of the oral palate by way of the palatine foramina is also to be seen, but is much less evident. There are no clinical details.

Case 7.—BICKERSTETH'S. This case is fully recorded by Dr. Murchison in the *Pathological Society's Transactions* for 1866, xvii, 243.

The specimen is in the Museum of the Liverpool Royal Infirmary, and casts of it are in the R.C.S. Museum, the Middlesex Hospital, and the Leeds Medical School (*Fig.* 245). An illustration of the patient is given in the *Liverpool Med.-Chir. Jour.*, 1857, i, 264.

The patient was 34 years old when he died, in 1857. At the age of 14 the bones of the face were first noticed to be enlarged. Three years later he was an in-patient at St. Thomas's Hospital for this enlargement. The swelling gradually increased, and thirteen years after its commencement a similar hard swelling appeared along the course of the left fibula. Apart from the

unsightliness, the swellings caused the patient little inconvenience until two years before his death, when he began to suffer intense pain in the leg, and pain, less severe, in the head. He became gradually emaciated, and as the facial enlargement increased, the cavities of the mouth and nose were greatly lessened, and the eyeballs protruded even beyond the lids. The sight of the right eye remained good, but that of the left was lost.

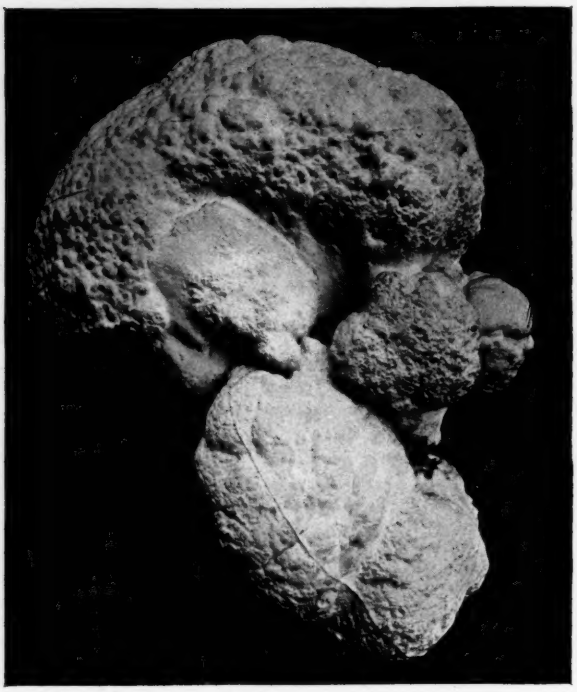

FIG. 245.—From a cast of the skull of Bickersteth's case (R.C.S. Museum, No. 1359.1, Gen. Path. Sect.). The photograph was taken to show that the disease has spread from the lower jaw back to the skull. An isolated area of periostitic deposit is seen on the otherwise normal temporal bone in immediate relation to the temporo-mandibular joint.

The mobility of the lower jaw was but slightly interfered with, and mastication and deglutition were performed without difficulty. Smell and hearing were not affected, and the intellect was unimpaired. In the end he became suddenly comatose without evident cause, and died. Death was attributed to exhaustion, emaciation, and protracted suffering. At the post-mortem the internal organs generally appeared healthy. The patient had never suffered from syphilis, and there was no history of tubercle or constitutional syphilis or cancer in the family. A brother had a similar enlargement affecting one upper jaw, which began about the age of puberty, but had remained stationary for many years.

In addition to the enormous deformity of the skull and lower jaw, which is very like that in Fourcade's case, the hyoid bone was also affected. The tumour of the fibula, whose cross-section measured $5\frac{1}{2}$ in. by $4\frac{3}{4}$ in., sprang from the posterior and inner surface of that bone by a narrow neck (determined by fascial attachments ?) and it may be noted that it showed a canal on its inner side, evidently for a vessel of considerable size. Its characters have already been described (page 352). Part of this tumour is in the Middlesex Hospital Museum (C 133).

Case 8.—Of five cases of leontiasis ossea recorded by Victor Horsley (*Practitioner*, 1895, lv, 1), his third case is the only instance of the periostitic variety. It had a very interesting history.

The early part is given by Bland-Sutton (*Trans. Clin. Soc.* 1889, xxii, 266). A man, age 24, came under his care in the Middlesex Hospital in September, 1888. He was five feet high and appeared to be stunted by rickets. Five

years before a swelling had appeared in the neighbourhood of the nose without any known cause. Two months later the right ascending ramus of the lower jaw became affected, and gradually the face became deformed by the projecting masses on each side of the nose. The swellings caused no pain, but gave rise to inconvenience from nasal obstruction. On Oct. 3, 1888, the affected part of the right lower jaw, which had increased rapidly of late, was removed subperiosteally (i.e., the portion posterior to the 2nd bicuspid). At the patient's request the right upper jaw was removed on Oct. 20—an operation justified by the complete obstruction of the right nostril, some proptosis of the right eye, and failing vision (R.E.V. = $\frac{6}{36}$, J.16).

In 1890 he came under Horsley's care. The left side of the face was becoming enlarged and he often had neuralgic pain. There was only perception of light in the right eye, whilst the sight of the left was failing, and the disc was atrophic. Horsley's operation ended in a simple exploration, as he was not permitted to remove the upper jaw, which was the only treatment likely to benefit.

The illustration in the Clinical Society's *Transactions* shows that this was a well-marked case of the periostitic form of leontiasis ossea. In the upper jaw the antrum was obliterated, and the thickening involved all parts of the bone alike.

As the failure of vision advanced after his operation, Bland-Sutton concluded that the optic nerves were undergoing slow compression in their passage through the sphenoidal bone.

Case 9.—James Young, Bristol, recorded the following case (*Brit. Med. Jour.*, 1896, Oct. 31, 1303).

The patient was 39 when the disease first appeared, and no cause could be assigned by him or his friends. The upper jaws were thickened generally and the protruded masses on them were tender. There was distinct prominence and thickening of the supra-orbital ridges, more marked on the right side; and also exophthalmos and ectropion. His mental condition has been described on p. 351; he died at the age of 46. Post mortem the frontal sinuses and antra were occluded, and the orbital cavities diminished. The nasal cavity was filled right up by encroachments of bosses of bone on each side. The right superior maxilla was considerably thickened along its alveolar margin. The bosses of bone protruding from the upper jaws were found on section to be cancellous in structure. The kidneys were granular.

Case 10.—Specimen in St. Mary's Hosp. Museum, No. 91.72, from a dissecting-room subject. No clinical notes.

In this instance the frontal and sphenoidal bones are more severely affected than the others. The malar, superior maxillary, and nasal bones are involved to a considerable degree by extension, but both antra persist.

The frontal bone is greatly thickened, being one inch or more thick in places at the section through the brow. The frontal sinuses are completely filled, and the whole section shows a dense, finely porous surface with no differentiation of either table. The signs of involvement of the sphenoid are unusually marked. Rounded masses correspond to its orbital surfaces, and the periosteal deposit can be traced through the sphenomaxillary fissures to the temporal surfaces of the great wings. The interior structure of the right

wing is exposed and is dense like that of the frontal bone, whilst the intracranial aspect of the whole bone is particularly marked by numerous vascular foramina. There is also considerable deposit of periosteal bone in the nasal fossæ, but the blockage is not so complete as that seen in many of the previous cases. It seems probable that the focus of trouble lay in the frontal and sphenoidal sinuses and that infection spread chiefly from the posterior part of the fossæ to the orbits, which show extensive changes.

It is not easy to trace the path to the frontal bone. It may have been, and probably was, by way of the orbits, and assisted by the direct tracks made by the vessels and nerves. The infection has emerged at the anterior openings of the nasal fossæ, but this was probably only a late development, and the well-advanced condition on the vault can hardly have originated from it.

Another peculiarity of this specimen is the presence of two or three apparently isolated patches of periostitis near the parieto-occipital suture, but there are slight signs that this isolation is not quite so decided as it seems to be at the first impression.

Case 11.—Dr. Lediard's. This specimen (R.C.S. Museum, 1361.1, Gen. Path. Sect.), a portion of a lower jaw, is valuable because it shows the first part of that bone to become involved.

It was removed from a woman, age 45, in 1902. Bony prominences had existed on each side of the bridge of the nose for 20 years. They originated in the superior maxillæ, and gave the face a frog-like appearance. They had become stationary. The enlargement of the lower jaw had been noted for three months, and showed evidence of activity. The patient died after the operation.

The enlargement extends from the symphysis to the angle, and affects chiefly the outer aspect and lower border. It is evidently the result of periosteal deposit, for the original body of the jaw can still be recognized vaguely in the cross-section, though it blends with the new bone. All the molars and premolars are absent, and the alveolar process and the tooth sockets have disappeared.

Case 12.—No. 398, St. Bartholomew's Hospital Museum, is "a superior maxillary bone in which the cavity of the antrum is completely filled up by a growth of porous or very finely cancellous bone. The cavity is represented by a linear track opening into the middle meatus. There is periosteal deposit on the external and orbital surfaces, and also on the posterior surface traceable from the pterygopalatine fossa. The lateral nasal wall is considerably affected, and the nasal duct opening is represented on the under surface of the bulging formed by the altered inferior turbinate bone. The antrum was probably the focus of the disease in this case. It was from a girl, age 15 years. Enlargement of the nasal process of the superior maxilla had been observed for eight months and was increasing. The disease was painless and the general health good. Death occurred from erysipelas ten days after removal of the upper jaw." (*See* Stanley, *Treatise on Diseases of Bones*, 297.)

Case 13.—No. 399, St. Bartholomew's Hospital Museum, consists of portions of a superior maxillary bone which before division formed a nearly spherical mass of hard, heavy, and cancellated bone. There is no smooth surface on any part of the various portions to suggest an exostosis.

It was taken from a man, age 37. A smooth prominence of the nasal process of the right superior maxilla had been noticed for two years, but it was not increasing. He was admitted with what appeared to be necrosis of the alveolar portion of the jaw and suppuration around it. After four months the mass of the bone which occupied the position of the antrum completely separated and was removed. The cavity, which opened widely into the mouth and nose, gradually contracted and the man recovered. This case is described in Sir James Paget's *Lectures on Surgical Pathology* (old catalogue No. 1.260).

There is insufficient evidence to assign this case to the periostitic or the osteitic group, but it no doubt belongs to one or the other.* It is quoted here to show that septic infection may complicate these cases on rare occasions.

II. DIFFUSE OSTEITIS OF THE BONES OF THE FACE AND SKULL.

(*Osteitis Fibrosa.*)

This form of leontiasis ossea results from a peculiar inflammatory affection of the medulla (i.e., the soft tissues occupying the cancellous and diploic spaces and Haversian canals) and has certain very distinctive features :—

1. *The Complete Absence of any Periosteal Bone Deposit.*—This is the most striking feature, and the one which distinguishes it at once from the other variety—namely, creeping periostitis.

2. *The Character of the Change in the Shape of the Affected Bone.*—It is enlarged, often enormously, but the enlargement gives the impression that the bone is swollen. The resemblance to the normal bone remains, but the salient points that give the latter its 'expression' disappear. The bulky bone distends its periosteal envelope so that its fossæ are filled up, and sharp ridges and elevations are rounded off. The suggestion is conveyed that the change of shape must have depended upon an alteration in the consistency and firmness of the osseous tissue.

3. *The Osseous Tissue presents Definite Characters.*—The bone, especially in the early stages, is vascular and soft. In the cranial bones vascularity is very noticeable. If the bone is exposed during an operation, the hæmorrhagic colour and mottling are conspicuous beneath a thin or perforated surface, and indicate the extent of the morbid process.

When this appearance is present the bone is very soft and can be cut or gouged away, or penetrated with a trephine without any trouble. In the later stages, when ossification has advanced considerably, the bone becomes firmer, but even in the 'Bristol' skull it was stated to be 'markedly' softer than normal.

The surface of the bone is smooth, but it does not present the smoothness and polish of compact bone. When carefully examined it is seen to present innumerable apertures, but there are areas where these are much less in evidence. Such areas are the remains of the compact tissue, whose absorption is brought about from within (*see Fig.* 249). The innumerable apertures

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* In the Atlas (1877–79) of the Musée Dupuytren, plate 41, there is an illustration of a skull showing a marked degree of the periostitic form of leontiasis ossea. Its number is 384—Professor Cruveilhier's specimen.

represent the surface of a cancellous tissue of new formation, which has taken the place of the original bone (compact—cancellous—diploic), and is permeated by a vascular connective or fibrous tissue medulla which blends with the periosteum. The foramina certainly transmit vessels, but they are filled with this soft tissue as well.

The appearance produced by this change on the surface of the bone has been likened to that of coarse woollen cloth, and it is well shown in the photograph of the lower jaw of the 'Bristol' skull. Little buds of osteogenic tissue, which is what the medullary tissue has now become, protruding from these apertures, may ossify, and when this happens a very finely mammillated surface results which might easily be mistaken for periosteal deposit.

The cranial bones may be enormously thickened. The width of a cross-section has amounted to 3 in. The inner and outer tables (or in other bones the compact surface) cannot be differentiated, and the face of the section is composed of finely porous bone of varying degrees of density, and of similar character to that exposed superficially by the disappearance of the compact tissue. The homogeneous aspect of the section may be interrupted by some scattered patches or tracts of soft fibrous-looking material, and in rare instances cystic degeneration of such a patch may be seen.

In the 'Bristol' skull, where the disease was of many years' duration, patches of very dense bone, and spaces from which soft tissue has been removed by maceration and from which softened contents escaped after the bone was divided, are dotted about in the general expanse of cancellous tissue of varying degrees of density. This appearance points to an ossification which has been irregular in its incidence, of long duration in some parts and much shorter in others, and it may be compared with unmacerated specimens in which fibrous patches are present in a mass of osseous tissue of uneven density (*Case* 12, *see Fig.* 254).

4. *Age of Onset.*—The age at which the disease first manifests itself is usually in the first or second decade of life. The disease is clearly one of young people, and the exceptions are met with more commonly in those cases in which the jaws are primarily involved as a consequence of dental irritation (*Group C*).

Cases of the osteitic form of leontiasis ossea fall into three definite groups :—

Group A.—A general diffuse osteitis of the cranial and facial bones.

Group B.—A circumscribed osteitis of one or more cranial bones or of a part of one.

Group C.—An osteitis beginning in one or both jaws and rarely spreading far beyond them. This group is associated with dental irritation in most cases.

Group A.—General Diffuse Osteitis of the Cranial and Facial Bones.

Instances of this remarkable affection are not numerous.

Case 1.—The following description of a skull in the Museum of the Bristol Royal Infirmary (No. 141) is taken from an article by Stack, who recorded the case in the *Bristol Med.-Chir. Jour.*, 1900, xviii, 316 (*Figs.* 246–249). The patient's photograph represents her with a very prominent overhanging

FIG. 246.—The 'Bristol' skull. Showing the smooth surface and persisting sutures.

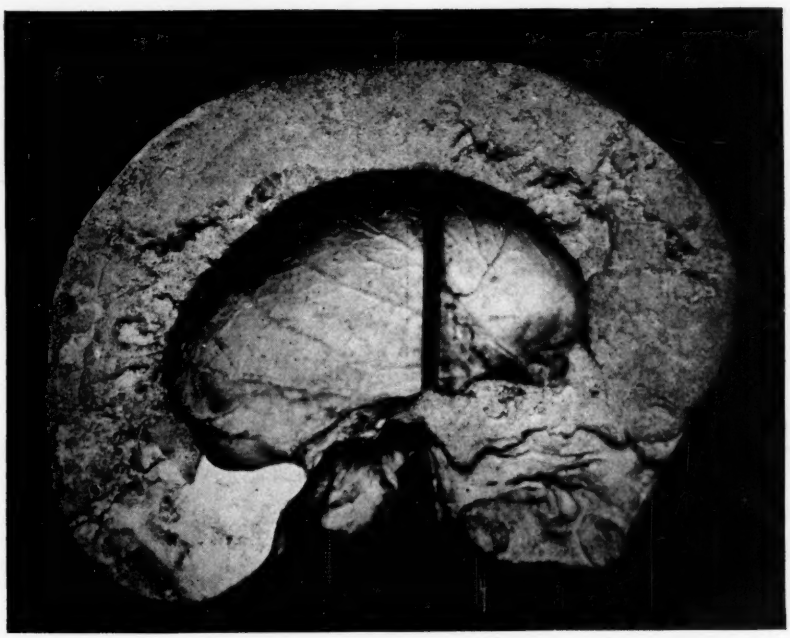

FIG. 247.—The 'Bristol' skull: sagittal section. With a magnifying glass the persistent fronto-ethmoidal and parieto-occipital sutures can be seen.

forehead and an enormous protruding lower jaw. Though the facial bones were affected, the face itself appears insignificant between these two marked deformities. The half skull without the lower jaw weighed 7½ lb., and the lower jaw 1 lb.

There was enormous thickening of the vault and base, and this attained its maximum in the cerebellar region, where the width of the section was 3 in. The outer surface was quite smooth and the internal fairly normal. The bones of the skull were for the most part markedly softer than normal, but the appearance of the section was not quite homogeneous. In parts there

FIG. 248.—The 'Bristol' skull: front view. Showing the diminished orbit and absence of the alveolar process.

FIG. 249.—The 'Bristol' skull: lower jaw. Showing the patches of compact bone contrasting with the darker coarse 'woollen cloth' appearance where the surface is porous, and also the eroded opening into the hollowed portion of the interior.

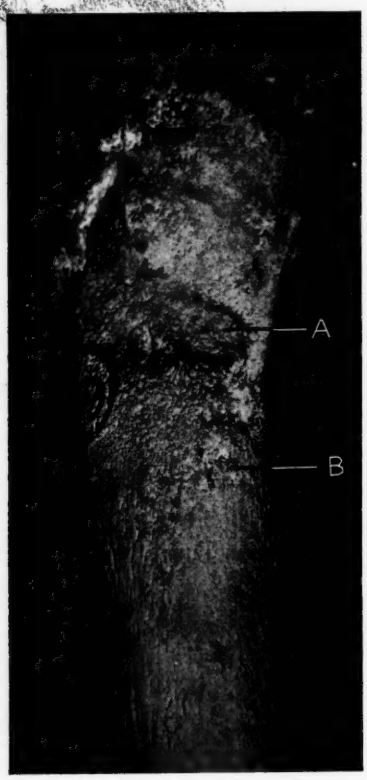

FIG. 250.—The upper portion of the right tibia of the Bristol case. Showing a part (A B) where the compact surface has been eroded from within. With a magnifying glass a much better idea of the condition can be obtained.

were masses of more compact tissue, and in others there was rarefaction to such an extent as to leave spaces of ⅛ in. diameter. The lower jaw had a

few temporary teeth (age 21) on its upper surface where the alveolar ridge had been. The body was enlarged and rounded, and the compact shell, expanded and filled with very porous bone containing a quantity of slimy, gummy material which poured out when the bone was cut into. Several of the permanent teeth were buried in the under surface of the bone quite on its lower aspect.

Notable changes were also present in some other bones. The pelvis was generally contracted and markedly beaked and twisted, the sacrum being deflected to the right. There was slight scoliosis, but the vertebræ and ribs were normal in consistency. The femora were slightly bent and softer than natural. The right tibia was bent laterally, chiefly at the lower end of the upper third, and there was also a slight anteroposterior curve of the whole bone; the outer face of the upper articular surface sloped downwards and outwards, and a marked genu valgum had been present on this side.

Clinical History.—The patient, a female, age 21, was admitted to the Bristol Royal Infirmary under Dr. Waldo in December, 1899, for sore throat and dyspnœa, and died the same night.

When 3 years old she fell, cutting her forehead, and was in the General Infirmary for several weeks. At 7 the mother first noticed the child's head to be larger than natural. At 12 she had the right canaliculus slit up for dacryocystitis. At 19 she fractured the lower end of the right femur, which united in two months. The mother thought the lower-jaw deformity began at the same time as that of the head. Mentally she was all right, and a great help to her mother, though she tired too easily to be of use in the housework. She never had any fits, and there was no sign of syphilis in either parent or in other children. She died from diphtheria after tracheotomy, and the dyspnœa was in part due to a firm fibrosarcoma containing numerous giant cells which grew from the posterior surface of the hard and soft palate.*

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* Having made recently a careful examination of the preserved and macerated bones from this case in the Museum of the Bristol Royal Infirmary, I can now give the following additional details.

No. 141, *Left Half of the Skull—Sagittal Section.*—The outer surface (*Fig.* 246) is smooth with a certain amount of tracery upon it, partly from periosteal vessels, partly from papillary mammillated hemispherical points (mustard seed). This papillary condition is present particularly over the lower part of the frontal bone and over the surface of the temporal fossa and anterior part of the mastoid process. It suggests small bulgings of medullary tissue (osteogenic) through thinned and perforated compact tissue which have subsequently ossified. There is no sign of their being due to periosteal deposit—indeed, on the face of the cross-section an external table can hardly be considered to be present.

The inner surface of the skull (*Fig.* 247) is also smooth, but not polished, and shows no sign of periostitis; the arterial grooves are deeper than normal and sharply defined. The bony canal for the middle meningeal artery is very marked. The jugular foramen is considerably contracted, apparently by expansion of the bones which form it, and a considerable foramen, evidently for an emissary vein of large size, is situated in the floor of the lateral sinus groove and opens on the under surface of the occipitomastoid suture. It suggests an established collateral venous circulation. Other foramina are but little altered if at all. The lateral sinus groove is very indistinctly marked. The whole body of the sphenoid bone is enlarged and the pituitary fossa is very shallow. The petrous part of the temporal bone is the least changed of all the bones.

The following additional particulars may be added: Occipitofrontal circumference $31\frac{1}{4}$ in., suboccipital circumference $30\frac{7}{8}$ in. In Sir James Paget's case of osteitis deformans

Case 2.—The Jadelot—or the Sacy—skull (*Figs.* 251, 252) can be traced back to 1745. It was found at the village of Sacy near Rheims, 15 feet deep in the ground. In 1799 Jadelot gave a full description of it, and this is reproduced in part by Paul Gervais in an article on "Hyperostosis in Man and Animals" (*Jour. de Zoologie*, 1875, iv, 272). The specimen is in the anthropological section of the National Museum of Natural History, Rue de Buffon, Paris.

Presumably the skull only was found, for it was taken for a giant's until

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the circumference at the level of the middle of the temporal fossa was 26½ in. That of an average skull is 21 in.

The Sutures.—The squamous portion of the temporal bone is markedly affected, bulging externally, whilst the squamoparietal suture marks the bottom of a considerable depression with sloping sides. The occipitoparietal suture is also well-marked, and can be traced across the surface of the section into the suture on the interior of the skull. The coronal suture is well seen, but cannot be traced across the section. The suture between the lesser wing of the sphenoid and the orbital plate of the frontal bone is separated (apparently in maceration). The nasal bone shares in the general enlargement, and the sutures in connection with it are clearly seen on the section and on the face.

The Air Sinuses.—There is no trace of the frontal. The bone in its situation is minutely porous, and passes gradually above into irregular spaces with here and there patchy areas of dense bone of various size. The sphenoidal sinuses are only represented by irregular spaces in a mass of porous bone. There is no compact lining to these spaces, but rarefied cancellous tissue projects into them. The part below the pituitary fossa is completely filled up.

The Orbit.—The edges are rounded and smooth. The walls are smooth, but show similar tracery to that on the vault. It is contracted in its circumference but increased in depth. The sphenoidal fissure, the optic foramen, and the sphenomaxillary fissure are of good size, but the latter is more deeply placed in the orbit than normal, owing to the hypertrophy of the malar bone. The nasal duct is doubtfully obliterated.

The Jaws.—The upper jaw is enlarged. The alveolar process has disappeared (*Fig.* 248). The palatal plates of this bone and the palate bone are nearly 1 inch thick, and show two cavities for teeth displaced towards the nasal floor. The pterygoid plates of the sphenoid are enlarged and fused with the palate bone and the hollows are filled up.

The body of the lower jaw (*Fig.* 249) forms a large rounded swelling much bigger on the left side. The enlargement diminishes in the ascending rami and shades off into the coronoid processes. The condyles and necks are practically normal. The specimen is somewhat crumbled, and there is a considerable cavity in the left side of the body having eroded openings in front and behind. The boundaries of this cavity are formed of irregular and rarefied bone which is elastic when compressed. Opening on the under surface are three cystic cavities—probably associated with teeth. The compact surface of the bone has disappeared except for thin patches or tracts, and the porous rarefied bone exposed gives the coarse woollen cloth appearance. There is no sign of periosteal deposit. A cross-section through half the width of the body has been made. This shows a very fine cancellated structure throughout, except in the central part of the bone where the spaces are larger.

The Right Tibia (No. 249).—Some details have been given in the text. In addition it should be noted that the compact tissue has been thinned and eroded in many places (*Fig.* 250). These appear as roughened areas, but with a magnifying glass they are seen to have been produced by absorption of the compact tissue and the exposure or formation of a finely reticulated cancellous tissue, and not by a deposit of periosteal bone. The most marked portions are situated on the inner and posterior surfaces of the upper fifth, and in the lower half in patches on the posterior and external surfaces.

Necropsy.—The body was ill-nourished and suggested an age of 14 or so instead of 21. The brain was normal and weighed 47 oz. All the other organs were healthy in appearance except: (1) The liver, which showed on its surface several small growths scarcely larger than tubercles, and in its interior a few larger ones, the largest of which was as big as a small marble. These showed the same microscopic structure as the liver tissue, namely, fatty infiltration with diffuse cirrhosis—a condition that raised the question of congenital syphilis. (2) The right thyroid lobe contained a mass which resembled exophthalmic goitre in its microscopical structure. (3) The myeloid sarcoma springing from the hard palate has been referred to. (P.M. Book 16, p. 36).

Jadelot showed from its dentition that it was that of a child of only 5 or 6 years of age. Though the greater part of the teeth are missing, the alveoli

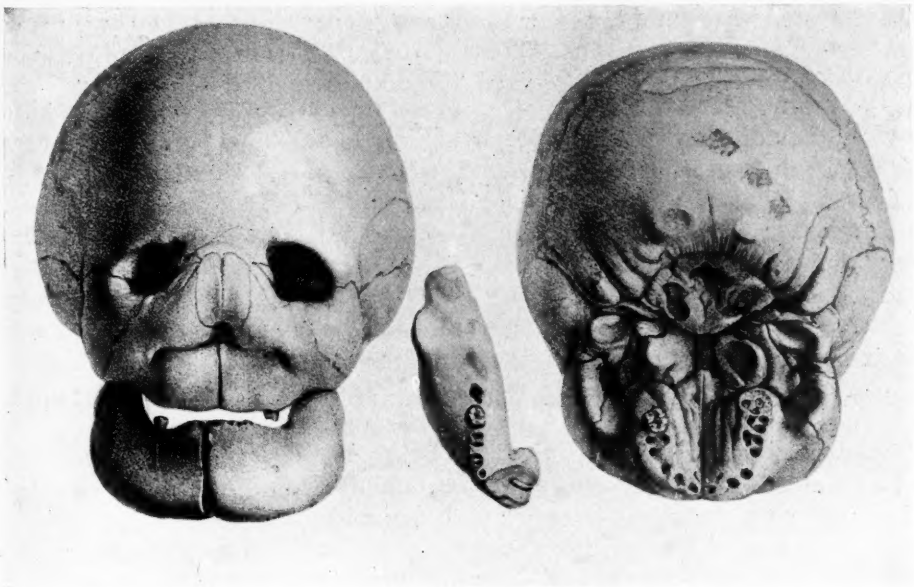

FIG. 251.– The Jadelot or Sacy skull. (*After Gervais.*)

pointed to 20 milk teeth and 4 permanent molars. Jadelot's conclusion, however, cannot be implicitly accepted, for fibrous osteitis, which I believe to be the explanation of these cases, when it affects the jaws, plays havoc with the dental arrangements.

Jadelot and Gervais believed that the other bones were affected, but this is evidently pure assumption. If they were, as in the Bristol case, it is almost certain that they were not hypertrophied. The cranial bones are stated to have attained an extraordinary thickness.

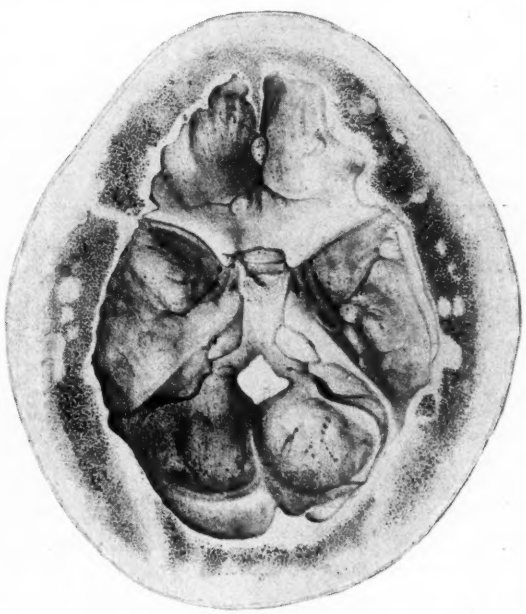

FIG. 252.— The Jadelot or Sacy skull. (*After Gervais.*)

The drawings which accompany Gervais's paper show that the exterior of the skull had a smooth surface like that of the 'Bristol' skull, but on the internal surface of the base the bones presented a swollen appearance which modified the foramina and especially the foramen

magnum. A horizontal section showed that the cranial walls were everywhere thickened. This thickening amounted to as much as 3·5 cm. or more. At the occiput it was 3 cm., on each side of the frontal bone 2·5 cm., and at the vertex 3 cm. The thickened walls are said to have preserved in part their diploic structure.

From the measurements of a cast of the brain cavity, Gervais deduced that the brain exceeded the average ordinary dimensions in the adult, and that the child, in addition to the hyperostosed skull, was also to a certain degree hydrocephalic (loc. cit., p. 464). The presence of Wormian bones might be considered to have lent a little support to this idea.

A microscopical account is also given, and the bone is stated to have had a very different structure from that of healthy osseous tissue. From the description it would appear that the bone trabeculæ were not laminated, that they were formed from fibrous tissue, and that the bone cells were not stellate. This is evidently very similar to the new bone formation in osteitis fibrosa.

Case 3.—This is recorded by Ilg (*Einige anatomische Beobachtungen*, Prag, 1821).

Barbara Rudolf was one of eight living healthy children whose father died at the age of 30 from consumption, and the mother at 60 with dropsy. In her 10th year she began to suffer from headache and epilepsy. She became deaf in both ears at 16, and from that time her head was noticed to be getting bigger and she had difficulty in lifting it. From her 17th year she was unable to take solid food, and about the same time outward curvature of the leg bones developed. She suffered from loss of smell, became bad-tempered and imbecile, was confined to bed, and died suddenly in her 27th year.

Ilg's drawings show the base of the skull to be almost a facsimile of the base of the Jadelot skull, and the outer surface of the vault and face to have the same even surface, whilst the cross-section of the vault was enormously thickened. (*See also* PAGET, *Med. Chir. Trans.* lx, 62.)

Case 4.—Dr. Shore has drawn my attention to the cast of a head in St. Bartholomew's Hospital Museum (Casts, No. 1).

Its resemblance to the 'Bristol' and the Jadelot skulls is so exact that there can be no doubt it was taken from a skull affected by the same disease. Unfortunately nothing is known about the case from which it was taken.*

What is the nature of the disease in this group? With the removal of all the soft tissue by maceration it must be largely a matter of inference. There are, however, certain facts to help us: (1) The original bone evidently has disappeared and the hyperostosis is produced by a new formation. (2) In

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* In the Atlas of the Musée Dupuytren for 1842 there are four illustrations of a skull, which is almost certainly another instance of the osteitic form of leontiasis ossea. The whole cranium is affected and the foramen magnum is much deformed. A description is given in the catalogue accompanying the atlas, under No. 378. It was from a man, age 65 years, of small stature and good intelligence, who had always had a head so large that he could not find a hat to fit. The rest of the skeleton presented no abnormality. The hypertrophy was limited to the cranium and did not extend to the face. This led M. Andral, who presented the specimen, to suggest that it might exemplify a method of cure in hydrocephalus.

Huschke, in an article on "Cranio-sclerosis totalis Rhachitica" (Jena, 1858), gives four plates representing a cranium with a left malar bone showing the smooth surface and thickening seen in the 'Bristol' and Jadelot skulls.

this new formation it is clear that the ossifying process is irregular both in distribution and in point of time. (3) Putting the irregularity of ossification side by side with the uniform thickening of the bone, it is evident that an intermediary tissue is formed as the old bone vanishes and before the new bone forms, and that it is in this intermediary tissue that ossification proceeds.

In the succeeding groups it will be seen that there is no question that the disease is osteitis fibrosa, and there can be hardly any doubt that this is the form of osteitis which is responsible for the general diffuse affection. The features just mentioned are those of osteitis fibrosa, and the inference is supported by the alterations present in the other bones of the 'Bristol' case, and by the microscopical appearances of the bone in the Sacy skull.

Group B.—Circumscribed Osteitis of One or More Cranial Bones.

This form usually begins as a localized swelling, shading off into the normal bone. It gradually invades the whole bone, and it may, if not interfered with, spread beyond it and involve adjacent bones. The connection of this group with osteitis fibrosa is quite definite, and in one instance the cranial manifestation was only part of the generalized form of that disease.

Case 5.—In my Hunterian lecture on osteitis fibrosa (*Brit. Jour. Surg.* 1923, x, 487) I have described a case that came under my care in the Leeds General Infirmary. A girl, age about 16 years, had a swelling on the frontal bone which was so small that its removal was accomplished by a trephine with a very large circle. This cut through the bone with the greatest ease. The microscopical characters were those of osteitis fibrosa.

Of the five cases recorded by Horsley in the *Practitioner* (1895, lv, 12) one has already been given amongst the cases of 'creeping periostitis'. The other four are probably all cases of osteitis fibrosa, but only two (Horsley's 2nd and 5th cases) were examined histologically.

Case 6. (Horsley's 2nd case).—E.C., age 26, was admitted with a swelling on the left side of her head near the middle line in front of the coronal suture. It had been coming on for about five years and was not painful at first, but latterly had caused some pain of a shooting character over the vertex. It was removed on May 26, 1888. The dura was laid bare over an area as big as a shilling. Recurrence followed, and on April 9, 1894, the tumour was again exposed. The bone forming it was highly vascular, and its limits could be defined by the increased vascularity. The whole of the disease was cut away by a trephine and bone forceps.

Case 7. (Horsley's 5th case).—H.D., age 35, was admitted to University College Hospital on March 18, 1895, with a swelling on the right side of his forehead. Fourteen years before he fell from a tree, and the next day a swelling appeared over the right eye, with redness and pain, and was said to be erysipelas. It subsided in a week. Though he did not remember striking his head he attributed the swelling to the fall; but a photograph showed that growth had begun at least three years previously. It occupied the whole right frontal region. The orbital margin was thickened and the tumour could be felt pressing the eye downwards, and this was also somewhat protruded.

On April 24, 1895, the tumour was removed by an extensive operation which included the cutting away of the major part of the great wing of the sphenoid and the upper part of the malar bone. The surface of the tumour was smooth and the bone vascular. The bone was softer than natural, and its thickest part was at the margin of the orbit, where it measured 1¼ in. The roof of the orbit was much thickened and the frontal sinus was obliterated.

Horsley pointed out that in every case: (1) the outer surface of the swelling was smooth; (2) the diseased bone presented a marked contrast to the normal, being notably more vascular and having its surface pitted with minute foramina, the branching of the superficial vessels being very prominent, and the colour a deep red as compared with the pink white of normal bone; (3) on section of the whole thickness there was no demarcation between tables and diploë, but the appearance was uniform; and (4) the medullary spaces appeared to be filled with a soft tissue, but yielded no marrow pulp.

The histological details are clearly of the same kind as those in osteitis fibrosa.

Of the medullary tissue, it is stated that in the outer portions of the tumour it consisted chiefly of a delicate fibrous tissue. From this, to one in which the whole medulla was converted into a dense feltwork of fibrous reticular substance, every stage could be found. The bony trabeculæ showed notable changes as soon as the medullary tissue became obviously altered, until in the most advanced areas of disease every bony trabecula showed a marked reversion to a chondroid stage and the margins and surfaces displayed many false Howship's lacunæ. At the periphery the trabeculæ were normal and the lamellæ were well marked.

The naked-eye features and interior of these tumours correspond closely with those noted in *Case* 5.

Case 8.—A fourth instance occurred in the same patient from whom those specimens were obtained which enabled von Recklinghausen to establish the identity of osteitis fibrosa. It is an important case, linking up, as it does, leontiasis ossea with osteitis fibrosa. The hyperostosis of the skull met with in that case is thus described.

"The head was lop-sided because the right occipital region was thicker than the left. The bone was 2 cm. thick here, but the skull was in general thin. Externally the surface could be indented by the finger. A section of the bone at this point was hollow. The cavity, like others near it, was surrounded by compact hard bone. It was filled partly with watery fluid, and partly with white soft fibrous tissue which lay in the middle of the space and sent processes to the smooth wall of the cyst" (*Virchow's Festschrift Assistenten*, p. 6).

It is a curious coincidence that Virchow, who showed the bones from this case at the 59th Congress of the Deutscher Naturforscher und Aertze in 1886, drew attention to the Sacy cranium described by Gervais in 1875, though it does not appear that he appreciated the true nature of the disease. (*Berliner naturforscher Sammlung*, 1886, Gen. Path. and Path. Anat. Sect., p. 307.)

The circumscribed form, when it affects the cranial bones, usually begins in the frontal, and is often limited to it when the case first comes up for

treatment; but occasionally the disease may attack and be limited to one of the other bones.*

Case 9.—Thus, Virchow illustrates a dense though lightly porous hyperostosis of the whole of the left half of the sphenoid which was found in a woman, age 35, who died of typhus and had slight exophthalmos (*Pathology of Tumours*, French translation, ii, 20).

Case 10. — This case was shown to me by Mr. Barrington-Ward at Great Ormond Street Children's Hospital. It was a boy of 6½ years, in whom the first signs of cranial disease were noticed in May, 1921. An enlargement of the left temporal bone developed and was thought to be sarcomatous. It was explored in February, 1922, and a piece removed for examination. In October, 1923, there was proptosis and also slight bosses on the frontal and parietal bones on the right side. The left inferior maxilla was affected. Skiagrams showed discrete rarefied patches in most of the long bones, on the left side chiefly, and these were particularly numerous in the bones of the hand and wrist. Some diminution in the temporal swelling had followed the insertion of radium.

Fig. 253.—*Case* 10. The section is only slightly magnified (× 17) so that as much as possible of it is brought into the field. It shows a continuous layer of bone of new formation in which irregular lacunæ, filled with connective tissue or fibrous marrow, are evenly distributed. Ossification has advanced beyond the stage of separate trabeculæ, and is still in progress at the edge of the lacunæ. In the illustration the latter are partially bounded by white lines caused by shrinkage. With a magnifying glass the structure of the bone, and the marrow, can be made out. It is easy to understand from this case and section how the thick hyperostosed skulls of *Group A* develop in osteitis fibrosa. (Mr. Barrington-Ward's case. Photomicrograph by Dr. G. H. Rodman.)

Through Mr. Barrington-Ward's kindness I am able to show a microscopic section from the piece of tissue removed from the temporal bone (*Fig.* 253). It is typical of osteitis fibrosa, but is chiefly intended to show the connection of the hyperostosed skulls of *Group A* with osteitis fibrosa.

* The ancient parietal bone (R. C. S. Museum, No. 693) found in Hunter's collection of fossils has usually been attributed to osteitis deformans. A careful examination, however, makes this doubtful. The bone is complete, and its four borders present well-marked sutural surfaces. It is reasonable to suppose that the bone was separated in its entirety from its connections by natural processes, and not by art or violence. In all probability it is the parietal bone of an individual who was too young to be the subject of osteitis deformans; and it is impossible to believe that it could have separated from a skull affected with that disease, in which the sutures of the vault are generally obliterated. There is

Group C.—Osteitis Beginning in One or Both Jaws and Rarely Spreading far Beyond.

The importance of this group lies in the fact that most of the cases are, or have been, associated with dental suppuration or irritation, and there can be no doubt that this had a great deal to do with the production of the disease.

The affection presents different aspects in the two jaws. The superior maxillæ are usually converted into masses of more or less solid bone, but in the mandible the disease presents a greater resemblance to that in the long bones. Large cavities are often present in the enormously expanded jaw, lined with very delicate cancellous bone. These cavities before maceration were no doubt filled either with fluid from degeneration of the fibrous tissue, or with fibrous tissue in which ossification was so little advanced that no bony trellis-work remained when the soft tissue came away during maceration.

The following cases will illustrate these statements.

Case 11.—The specimen (St. Bart.'s Hosp. Museum, No. 400b), was taken from a woman, age 38, who had noticed her upper jaw enlarged for twelve months. Some decayed teeth had been extracted three weeks before the operation. It is " a right upper jaw which has been sawn across to show its involvement in a dense bony mass which chiefly occupies the alveolar margin but extends up to the antrum and the floor of the nasal cavity ", which both seem quite healthy. On the face of the section a few small fibrous patches can be detected here and there, and the largest patch is situated around the site of one of the extracted teeth.

Under the microscope " the tissue of the growth resembles dense cancellous bone, the spaces being occupied by fibrous tissue with some mucoid degeneration ".

But in the next case the whole superior maxilla on the left side was affected, and the disease had spread to the opposite bone along the alveolar process and encroached upon the right antrum.

Case 12.—The specimen (R.C.S. Museum, 1360.2, Gen. Path. Sect.) is a left upper jaw whose antrum is completely obliterated (*Fig.* 254). It is

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much less difficulty in looking upon it as an instance of the osteitic form of leontiasis ossea (osteitis fibrosa). Separation of a suture during maceration is mentioned in the note giving a detailed examination of the 'Bristol' skull (*Case* 1).

In Horsley's other cases the frontal bone was also the chief seat of the disease.

Horsley's 1st case.—S. M., age 19, had some severe illness eight years before, nature unknown. Four years before had scarlet fever, and shortly after noticed his head bulging. From the age of 14 he had generalized epileptic fits three or four times a year. There was pain which became diffused as the swelling increased, and in the early stages vomiting occurred with the headache. The right ear was deaf (the temporal bone was affected), and there was obvious downward deviation of the eyes from the projection of the growth into the orbits. No operation.

Horsley's 4th case.—A female, age 13 years, had a swelling of the left frontal region six months ; it became painful one month before admission. There was double vision some time before the swelling was noticed. It was removed with the whole breadth of the orbital roof which was affected. A year later no further enlargement had taken place.

Keen's case (*Internat. Clinics*, 9th Ser., ii, 180).—A girl, age 10. Six years before, the left eye became inflamed and gave considerable trouble. Shortly after, swelling was noticed in the frontal region above that eye. As it increased the eyeball was pushed downwards and optic neuritis developed. At the operation the skull was found enormously thickened (3 cm.) and so soft that it could easily be gnawed away with forceps or shaved off with a scalpel.

obviously an example of osteitis fibrosa. An anteroposterior section has been made through the bone, and the outer half is shown. The enlarged bone bulges roundly in front, at the side, and behind, but not towards the orbit. The face of the section is composed of dense, finely porous bone. Fibrous areas or tracts are numerous, and some are more or less sharply margined. In the alveolar region the bone and fibrous tissue are more evenly blended, and the bone spaces are larger than elsewhere and of a deeper colour, as if more vascular. In the anterior part of this region a patch is undergoing cystic degeneration, its margin and septa being fibrotic. The 2nd molar is half destroyed by caries, but there is no sign of pyorrhœa.

The microscopical examination of one of the fibrous patches "showed it to consist of bundles of cellular connective tissue, the closeness of which varies. In it there are well-formed capillaries and capillary arterioles with a single layer of circular muscular fibres".

The jaw was removed from a youth, age 19 years, in May, 1919. He had noticed a small hard swelling of the left cheek two years before. There was no pain and no discharge. Carious teeth (1st and 2nd premolar and 1st molar) were extracted in February, 1918, and he attributed the trouble to this. For four months before removal the swelling had rapidly increased and was accompanied by epiphora on the same side.

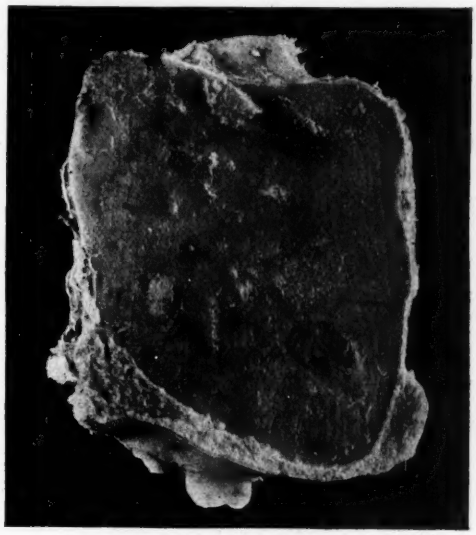

FIG. 254.—*Case* 12 (R.C.S. Museum, No. 1360.2, Gen. Path. Sect.). Section through the upper jaw, showing its transformation into a dense porous osseous mass in which are scattered masses of fibrous tissue, one of which in the lower part is undergoing cystic degeneration.

There are various macerated specimens of the upper jaw in different museums, in which an enlarged bone shows a section of finely porous osseous tissue extending to the surface, and an obliterated or diminished antrum. All tell-tale evidence of fibrous tissue, if any existed, has been removed by maceration, but the face of the section often shows spaces which are either artefacts, or may have been filled with fibrous material.

Case 13.—An upper jaw in the Leeds Medical School Museum (old No. A.64, new No. A.84) is of this type. The bone is much heavier than normal. Its grooves and fossæ have been to a great extent obliterated by the increase in thickness and density of all parts of the bone. Pyorrhœa has no doubt existed, for the 2nd molar is carious, and there is a trench around the other two molars in the alveolar border which contrasts with the normal in-setting of the other teeth.

Case 14.—A very similar specimen, to which Lord Lister's name is attached, is in the R.C.S. Museum, Gen. Path. Sect., 1360.1. It is a left superior maxilla

with part of the palate bone, which was removed by operation. The alveolar process and body have developed into a finely porous bony mass forming a smooth prominence on the outer surface. The flattened antrum is widely separated from the roots of the molar and bicuspid teeth, and its cavity lies against the thin normal outer wall of the nasal fossa. The 2nd bicuspid is carious, but there is no evidence of pyorrhœa, and the dental origin of the condition seems doubtful.

Case 15.—The following specimen was removed from a boy, age 11 years, who had noticed a swelling for two years. It is a dried right superior maxilla in which the antrum is obliterated, but the wall of the nasal fossa is normal and smooth. The outer surface is smooth except where its compact layer has been converted to finely porous bone like that displayed by a section through the specimen.

In connection with a root of the carious 1st molar there is an abscess cavity which has perforated on the anterior surface of the alveolar process.

It is stated that " the tumour under the microscope showed the ordinary structure of cancellous bone ". (St. Bart.'s Hosp. Museum, No. 400 a.)

Case 16.—The dental origin of the disease is not at all clear in the following. The specimen (St. Bart.'s Hosp. Museum, No. 400) is described as " a dense osseous tumour involving the whole of the left superior maxillary bone ", and was removed from a boy, age 9. The teeth present are healthy. The surface of the bone is smooth, and there is no differentiation of compact tissue from the dense porous structure of the interior. The antrum is obliterated, but there are two or three small patches or streaks of fibrous tissue which are suggestive of the nature of the disease.

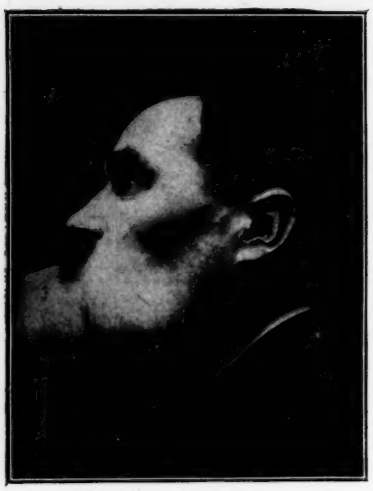

Fig. 255.—Photograph of the patient in *Case* 17.

The lower jaw is much less frequently involved than the upper in this circumscribed form of the disease. But when it is, there is a great difference in the amount of new osseous formation in its interior, and the relative enlargement of the bone is greater.

The enlarged and partially excavated lower jaw of the 'Bristol' skull (*see Fig.* 249) is a good example, and another is furnished by the lower jaw of an ape in the R.C.S. Museum, No. 711 V. Both these specimens are macerated, and show the very delicate character of the new bone trabeculæ.

Case 17.—There is an unmacerated specimen in the Leeds Medical School Museum (No. A.51 a) which is worth a more detailed description. Its histology is illustrated in a previous article on osteitis fibrosa (*Brit. Jour. Surg.*, x, 494, *Figs.* 400–2). The specimen itself is described in the catalogue as an " enormous central tumour involving the greater portion of the body of the lower jaw. The chief protrusion is outwards, where the outer shell of bone has been

completely absorbed. The tumour on section is hard, dense, and gritty, has a fibrous structure, and shows some signs of laminæ arranged in concentric whorls ". There are four back teeth on the right side which seem sound, but on the left side the last molar is carious.

The tumour was removed by Mr. Littlewood, in 1895, from a man aged 34 years, who had had a gradually increasing swelling of the mandible for fourteen or fifteen years (*Fig.* 255). An early photograph showed that it must have started near the symphysis. It was the only bone affected, and death followed the operation. Although it was originally regarded as an endosteal fibroma, recent histological investigation has shown it to be osteitis fibrosa.

Case 18.—In 1920 an elderly looking man, age 62, was shown to me by Sir Frank Colyer. He had a massive enlargement of the mandible involving the whole body, including the whole tooth-bearing area, but leaving the angles and ascending rami unaffected. The upper surface was rounded, and various teeth projected from it in a natural arrangement. There was a good deal of pyorrhœa, a probe passing down for quite half an inch alongside one tooth. In front of the body was a small area where fluctuation was obtainable through a thin pliable surface of bone. The alveolar processes of the superior maxilla were also much enlarged both on their outer and inner sides, and the roof of the mouth was transformed into an inverted-**V**-shaped arch. This condition had been developing for two years.

The shape of the cranium was remarkable. When seen sideways the frontal bone was much enlarged and elevated, and almost protruding, but the parietals did not share in the enlargement, and the skull shelved off into a normal shape behind the coronal suture. The skiagrams did not show thickening of the frontal bone, and this peculiar acrocephalic condition was thought by the patient to be natural to him. The temporal regions were unusually convex. This latter enlargement had not always been present, but he could give no help as to the date when it began. He was aware of the increasing size of his head because it became necessary to get larger hats.

He had a deviated nasal septum which blocked the left nostril, and had always been a mouth-breather. He was under treatment for deafness. The left clavicle was thicker than the right; but there was nothing else to raise a suspicion of osteitis deformans. He had never had syphilis. His general health was fairly good and he was quite able to carry on his work as a clerk.

Histology and Pathological Anatomy.—The histology of this form of leontiasis ossea is the histology of osteitis fibrosa. The original bone disappears, and an area much larger than that occupied by it, but still limited by a periosteal investment, is filled by a vascular and cellular connective tissue which in places, or in some cases, may become fibrous. In this tissue new bone develops, showing, at any rate in the early stages, no lamination, or a lamination produced differently from the ordinary lamination of bone (*see Fig.* 400, *Brit. Jour. Surg.* x, 494, from *Case* 17).

Its cells are rounded or triangular and not stellate like ordinary bone cells, and there are no regular Haversian systems. In some cases (*Case* 5) the new trabeculæ exhibit a peculiar character. Well inside their margin there can be traced an outline suggesting that one trabecula fits into a bigger

one like parts of a jig-saw puzzle. This appearance would seem to be produced in this way. After the formation of a defined trabecula, there takes place a further metaplasia of the surrounding fibrous tissue into bone, in some bulk, and not slowly by the gradual incorporation of cells. The linear boundary of the older part of the trabecula, however, maintains its sharp distinction and cannot fail to attract attention.

A curious phenomenon was seen in an upper jaw case. Globules or pellets of lime salts, stained deep blue with hæmatoxylin, were present in a part where metaplasia of the connective tissue into bone was in its earliest stage. The pellets were structureless, showed a tendency to cohere, and to become blended into a mass in which their globular outline was still visible. The connective tissue bounding such a mass would become condensed and take on the appearance of a trabecula with a pale blue stain. This exhibited the internal irregularities just described in which the influence of the conglomerated pellets could be detected. Such a trabecula might show at some part definite bone structure. In their mature form the trabeculæ showed the internal curvilinear tracery for which the globules were in part obviously responsible. (*Fig.* 256.)

FIG. 256.—Section from a portion of bone removed from an enlarged alveolar process of a maxilla resulting from septic teeth. It shows (1) a marrow composed of connective and fibrous tissue, (2) metaplasia of this tissue to form bone, in which are included (3) numerous pellets of deeply stained lime salts.*

Probably the pellets represented the unabsorbed calcareous débris resulting from the destruction of the original bone; otherwise we must suppose that there was some inco-ordination in the stages of ossification, lime salts being delivered in mass before the connective-tissue cells had acquired the power of utilizing them in the usual way. Similar calcareous pellets have been described and illustrated by W. H. Dolamore in a case which reads very much like one of osteitis fibrosa of the mandible in a man aged 30 (*Proc. Roy. Soc. Med.* xiv, 1920–21, Section of Odontology, p. 14).

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* The patient was a man, age about 40, in whom the disease, affecting both maxillæ, began in 1908. In 1919 he came under the care of Mr. H. Watson Turner. The teeth were bad and there was severe pyorrhœa. There was swelling of the alveolar processes on the inner and outer sides which caused protrusion of the lips and teeth. The latter were removed, and in 1920 the hypertrophied bone external to the dental ridge was cut away. In 1922 the patient reported excellent progress, and the facial deformity as very much improved.

The Tendency for Diffuse Osseous Formation to Occur in the Cranial and Upper Jaw Bones.—In the long bones affected by osteitis fibrosa there are usually considerable areas which to the naked eye are of a fibrous consistency and texture, though often gritty.

In the Hunterian Lecture on osteitis fibrosa I have regarded the presence of these tracts as of great value in establishing the diagnosis. In the cranial and upper jaw bones, however, there is only small naked-eye evidence of fibrous areas. Small patches or narrow elongated tracts may be recognized in unmacerated specimens, but as a rule the new bone formation completely overshadows the fibrous tissue; consequently, when the disease has been limited to one upper jaw, the enlargement has often been regarded as an osteoma; and when the cranial bones have been the seat of the affection, they have been regarded as the subject of some mysterious form of hypertrophy.*

Whilst the difference is obvious, it is not easy to explain it. It is possible that a better blood-supply may have some relation to the increased ossification. Thin bones with a vascular supply on each surface are probably better supplied with blood than a long bone whose interior is very largely dependent on that which comes to it through the nutrient artery. More blood would mean more toxins, and this might ensure a more rapid destructive effect upon the bone and would favour a more vigorous reaction.

When osteitis fibrosa is put forward as the explanation of such diffuse hyperostosis as is seen in the 'Bristol', the Sacy, and similar skulls (which it must not be forgotten have been macerated), there is a natural tendency to regard the suggestion with incredulity. But when it is remembered that in the upper jaw hyperostosis is the rule, and that in the cranium instances of the early and intermediate stages of hyperostosis are common, and where microscopically investigated are usually shown to be due to osteitis fibrosa, it does not seem at all improbable that, when the disease is of long duration, such remarkable instances of hyperostosis should result.

In microscopical sections taken from the cranial bones a prominent feature is the even regularity with which the trabeculæ are distributed, and the absence of large areas of connective tissue with few and scattered trabeculæ.

The section from *Case* 10, *Fig.* 253, is instructive. The trabeculæ have fused and are steadily growing at the expense of the intertrabecular marrow. It seems certain that if the process continues for any length of time, the greater part of the enlargement at present in being must be converted into a bony mass.

Pathogenesis.—The periostitic form of leontiasis ossea is in all probability the result of micro-organic infection. The osteitic form is almost certainly caused by toxins.

In the Hunterian Lecture referred to, the probable dependence of that condition upon toxic influence was discussed at some length. Consequently

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* Thus Ziegler writes: "The phenomenon is not unnaturally accounted for by the assumption that in these particular instances the periosteum and the marrow possess an inherited predisposition to excessive osteogenesis" (*Special Path. Anat.*, English translation, Vol. I, Sections 1 to 8, 219.)

there is little more to be said when it is recognized that the latter variety of leontiasis ossea is simply osteitis fibrosa affecting the cranial and facial bones.

The toxins which are responsible for such cases as those in *Groups A* and *B*, and possibly for some in *Group C*, are probably carried to the part affected by the blood-stream. But in many cases in which the disease starts in the jaws (*Group C*) the toxins have almost certainly a local origin, and depend upon some septic trouble about the teeth. This is an important fact, and points the way to prevention and possibly to cure.

In conclusion, I desire to acknowledge with gratitude the courtesy and kindness extended to me by the Curators of the various museums from which I have been permitted to obtain material for this article. My thanks are also due to those friends who have shown me cases and allowed me to make use of them, to others who have helped me, and to Dr. G. H. Rodman for the photomicrographs of two of the cases referred to. To Sir Arthur Keith and Professor Shattock I am under special obligation: to the former for encouragement and helpful suggestion, and to the latter for valuable direction, for the readiness with which he has allowed me to discuss difficult points with him, and for much kind help which it is unnecessary to particularize.

APPENDIX.

The following museum specimens, which are probably examples of osteitis fibrosa attacking the cranial and facial bones, have been regarded with special interest, because the nature of the disease producing them was uncertain.

Case 19.—In St. Bart.'s Hosp. Museum (No. 75) is the skull of a child, age 4 years, who died of bronchitis. He was of defective intelligence and unable to walk. There was no evidence of syphilis in the child or its parents, and the other children were healthy. The disease was limited to the skull, the bones of the trunk and limbs being unaffected. The peculiarities of the skull are probably explained by the early age at which the affection must have developed. The following description is taken from the catalogue.

"The specimen shows great thickening of some of the membrane bones of the vault and of some of those of the face. The cranium is asymmetrical, being unduly prominent on the right side in front, and on the left side behind. The sutures of the vault are synostosed. The calvarium is thickened everywhere, more in some regions than in others. Over the frontal and parietal eminences the thickness exceeds half an inch and the bones bulge externally. In the regions of the fontanelles and the sutures the thickening is less. There is thus some appearance externally of the condition described as Parrot's nodes. No distinction between the compact bone and the diploë can be discerned. The bones are uniformly dense and hard, though porous. Externally the surface is rough and pitted where the thickening is greatest—as over the parietal eminence—new periosteal bone having been deposited". (This pitted appearance is more probably the result of the changes occurring in the interior of the bone causing the substitution of porous bone for the normal external table.)

"The interparietal part of the occipital bone shares in the thickening which affects the membrane bones of the vault; the supra-occipital, like the other cartilage bones, is not thickened. The only membranous bones which have escaped are the squamosals: the thickening abruptly ceases at the squamosal suture. The cartilage bones of the basis cranii are not abnormal, the axis is not shortened, and there is no synostosis of the spheno-occipital synchondrosis. In the face the malar and superior maxillary bones are distinctly thickened and the inferior maxilla very much so, especially just in front of the angles.

"Dentition is natural." (All the milk teeth are present.) "The microscopical examination of the affected bone shows the ordinary structure of cancellous bone but with widened canals."

In addition it should be noted that there is a rough carious state extending over the whole of the hard palate on its oral surface, which has opened the sockets of two healthy teeth. Evidently there existed for a long time some very unhealthy condition of the roof of the mouth which may have been responsible for the changes in the skull as well as for the child's generally unsatisfactory state. Neither rickets nor syphilis will explain the specimen, and there would seem to have been no evidence of either. (*Group A* ?)

Case 20.—There is in the R.C.S. Museum (No. 711.V) the macerated skull of an elderly ape whose head had attracted attention for twelve years before he died. The hypertrophy is limited to the upper and lower jaws, and the frontal and parietal bones. The outer surface of the skull is smooth and porous, and the inner like it, but the meningeal grooves are deepened. The sutures are obliterated on the vault but not at the base. The fronto-parietal portion is about 1 in. thick, and the bone is of a uniform dense character, showing no differentiation of inner or outer tables.

The bodies of both upper jaws form large rounded swellings, and teeth are seen embedded at the orifice of the healthy nasal fossæ, and on the outer surfaces just below the malar bones. The alveolar processes have largely disappeared in front, but support a single molar on each side at the back. The frontal sinuses have been filled in, but the antra and ethmoidal cells remain. The body of the lower jaw is much enlarged and rounded and its alveolar margin has largely disappeared. A molar tooth is present on each side and opposes the corresponding molar in the upper jaw. Several permanent teeth are seen enclosed in cystic spaces, and a large empty space occupies the whole thickness of the jaw near the symphysis. (*Group B* or *C*.)

Case 21.—Close to the last specimen in the Museum is the half of the unmacerated head of another ape (No. 711.U). A fairly equal diffuse enlargement of the vault and base and upper jaw is present, and the ramus as well as the body of the mandible is much swollen. The orbit is not encroached upon. There are patches of soft tissue (fibrotic ?) dotted about on the face of the section, in the cranial vault, the nasal process of the superior maxilla, the basisphenoid, the basi-occipital, and in the lower jaw, and some are apparently undergoing disintegration. (*Group A*.)

SHORT NOTES OF RARE OR OBSCURE CASES.

TWO CASES OF ACUTE INTESTINAL OBSTRUCTION DUE TO IMPACTION OF GALL-STONES.

By CECIL P. G. WAKELEY, London.

Although all the leading text-books on surgery mention impaction of gall-stones as one of the causes of intestinal obstruction, it must be admitted that it is a rare condition. Two cases have recently occurred at King's College Hospital within six weeks of each other, but during the past ten years no such case was seen at this hospital.

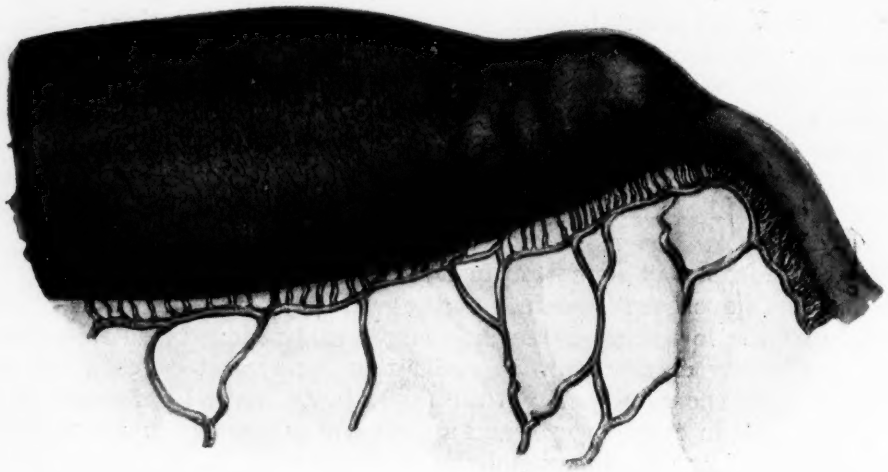

Fig. 257.—*Case* 1. Gall-stone impacted in the small intestine.

Case 1.—E. W., female, age 75, was seen on Feb. 1, 1923, complaining of abdominal pain and vomiting. She gave a history of fæcal vomiting with abdominal colic and absolute constipation for three days; there was an indefinite history of chronic indigestion, culminating on one occasion with a similar attack thought to be due to gall-stones. On examination the abdomen was distended and the temperature subnormal, and she was kept under observation. The bowels were absolutely confined, but there was much less pain

and no vomiting. Thirty-six hours later the patient began to vomit material which was definitely fæcal in character; operation was then decided upon.

A median laparotomy was performed; as soon as the peritoneal cavity was opened, distended small intestine protruded through the wound. A large gall-stone, subsequently found to weigh just under half an ounce, was felt in the lower end of the small intestine. The stone was closely held by a ring of spasmodic contraction of the gut; above this the intestine was greatly distended, whilst below it was emptied and narrowed (*Fig.* 257). The stone was pushed up the intestine for a short distance and then removed, the opening of the gut being closed by two layers of sutures. The patient made an excellent recovery.

This case is interesting in that the obstruction was not absolutely typical in its manifestations. The fæcal vomiting was intermittent, and the pain only severe when the vomiting was present. These facts, together with the actual finding of a ring of spasm gripping the stone, suggest that the intermission was due to the stone passing on for a distance, becoming held up, and then passing on again.

FIG. 258.—Gall-stones from *Case* 2. The one on the right was removed from the rectum, that on the left from the lower portion of the ileum. (*Natural size.*)

Case 2.—M. T., female, age 55, was admitted to King's College Hospital on March 29, 1923, suffering from intestinal obstruction. The patient stated that she had been well most of her life, but had suffered from occasional 'giddy' attacks during the last fifteen years. She had had almost complete constipation for a fortnight. She stated that she was always constipated, but never so bad as this. On examination, the patient was found to be large and fat, with an unhealthy complexion. The skin was moist and cold. The bowels were absolutely confined. The abdominal wall was so fat that palpation was difficult; however, there was marked resonance on percussion, general tenderness, but no rigidity. A soap enema was given, with a small result and the passage of a little flatus. On examining the rectum, a large gall-stone was discovered, too large to be passed naturally, and so it was removed digitally. The obstructive signs abated temporarily, and flatus was passed. However, after eighteen hours, fæcal vomiting recommenced, with abdominal pain. Operation was decided upon.

A mid-line laparotomy was performed, and a large gall-stone, considerably bigger than the one which was removed from the rectum, was found impacted in the lower end of the ileum about four feet from the ileocæcal valve. There was great distention of the small intestine. The stone was removed, and the intestine closed by two layers of sutures. It was found necessary to puncture the gut with a trocar and cannula before it could be replaced; the puncture was closed by means of a purse-string suture. The patient rallied after twenty-four hours, but died three days after the operation from paralytic ileus.

At autopsy well-marked paralytic ileus was present. The gall-bladder was firmly adherent to the first part of the duodenum. On opening the duodenum, two fistulous communications with the gall-bladder were found about 1 cm. apart; the upper one was smaller, and in all probability the stone which was removed from the rectum had ulcerated its way through it. The lower aperture was large and ragged, and the bigger stone must have forced its way through it. The two gall-stones are shown in *Fig.* 258.

I am indebted to my colleague, Mr. Arthur Edmunds, for the notes on *Case* 1, which was under his care; he also is responsible for the excellent coloured illustration.

A CASE OF INTESTINAL OBSTRUCTION IN A NEW-BORN INFANT, ASSOCIATED WITH AN UNUSUAL MALFORMATION OF THE SMALL INTESTINE.

By T. TWISTINGTON HIGGINS, London.

H. K., age 3 weeks, was admitted to the Hospital for Sick Children, Great Ormond Street, under the care of Dr. Poynton, on March 27, 1920. I am indebted to him for permission to publish these notes.

History.—The child appeared to be normal at birth, but vomiting began immediately and continued without intermission. The bowels were constipated. On admission, the child weighed 8 lb. 3 oz., and appeared in very good condition. There was remarkably little wasting. The baby vomited constantly quantities of bile-stained fluid. There was no action of the bowels before operation. A tentative diagnosis of high intestinal obstruction was made, and Dr. Poynton asked me to see the child with a view to laparotomy.

Operation.—Under ether and oxygen anæsthesia the abdomen was opened to the right of the middle line. The stomach, duodenum, and upper part of the jejunum were found to be markedly dilated, the remaining coils of small gut being collapsed. The terminal ileum and cæcum were found entangled round the jejunum and lying to the left of the duodenojejunal junction. It required a slight pull to free them from this point, though it was never quite clear how they came to be fixed there. The most likely explanation would appear to be that the gut had become partially herniated into a peritoneal pouch in this region, but such a pouch was never clearly

demonstrable. The ascending colon possessed a complete and lengthy mesentery. Following upon the disentanglement, there was obvious relief of the obstruction, the coils previously collapsed becoming rapidly distended.

Further systematic examination then revealed the following condition: the jejunum, about 10 to 12 in. beyond the duodenojejunal flexure, tunnelled through the mesentery of the ileum some distance above its termination (*Fig.* 259). There was no further obstruction at this point, the intestinal contents passing quite freely under the bridge, and it was therefore decided to leave well alone in view of the baby's condition. The abdomen was accordingly closed. The infant rallied from the operation satisfactorily, and as soon as possible was put on to hourly feeds of equal parts of peptonized milk and water. The bowels began to act normally two days after the operation, and the vomiting did not recur. Subsequent recovery was uneventful, and the baby was sent home on April 20, having gained 8 oz. It has been seen from time to time since, has developed quite normally, and has no intestinal symptoms.

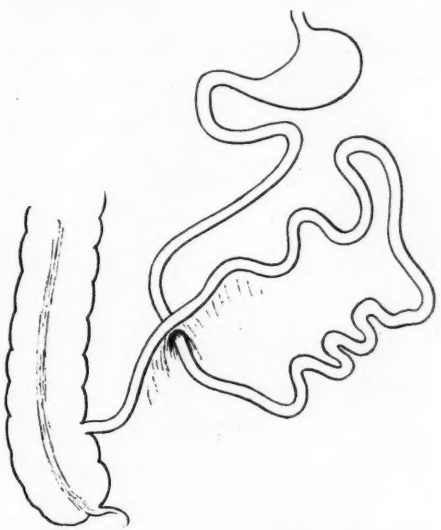

FIG. 259.—Diagram to show the position of the gut and mesentery.

Comments. — The nature of the obstruction in this case would appear to have been as follows: The ileocolic segment of the gut having become fixed in the upper abdomen, possibly by internal herniation, the lower pillar of the mesenteric 'bridge' (*Fig.* 259) was dragged upon, so as to produce an obstruction of the jejunum at the point where it passed beneath the 'bridge'. Release of the ileocolic segment relieved the obstruction. The complete and lengthy mesentery possessed by the ascending colon permitted such a wide excursion as was involved. But the chief feature of interest about this case is the malformation of the small gut and its mesentery. I have been unable to find a record of any case illustrating a similar defect. The condition evidently represents a divergence from the usual mode of developmental rotation of the intestine. It would appear that two rotations have occurred: (1) The normal one, whereby the colon comes to lie in front of the duodenum; (2) A second rotation in the same direction, whereby the small bowel has become transposed in such a manner that the lower ileum bears a relation to the jejunum similar to that of the transverse colon to the duodenum.

Such an abnormality is not included in the list of possible variations cited by Sir Arthur Keith.[1] Bearing on this point he mentions: (1) Cases in which rotation does not occur at all; (2) Cases in which rotation occurs in a direction opposite to the normal. In the former, the cæcum lies on the left side of the abdomen, and the ascending and descending colon is situated

behind and to the left of the small bowel. In the latter, the duodenum and mesentery come to lie in front of the transverse colon in place of being situated behind it.

In the case here related, the transverse colon was in its normal relationship to the duodenum, so that the primary rotation had pursued a normal course. A secondary rotation of similar type, but affecting the small intestine alone, seems to be the only possible explanation of the malformation in this case. Such a developmental anomaly is evidently exceedingly rare.

REFERENCE.

[1] KEITH, *Human Embryology and Morphology*, 4th ed., 300.

SACCULITIS OF JEJUNUM ASSOCIATED WITH ACUTE INTESTINAL OBSTRUCTION DUE TO EMBOLUS IN AN INTESTINAL BRANCH OF THE SUPERIOR MESENTERIC ARTERY.

BY A. PINNIGER AND C. E. L. BURMAN, LADYSMITH, NATAL;
WITH A NOTE BY PROFESSOR CHARLES F. M. SAINT, CAPE TOWN.

SACCULITIS of the large bowel is not of uncommon occurrence, but the condition arising in the first part of the small intestine in such a marked degree is of sufficient interest to warrant this case being placed on record.

HISTORY.—G. L., age 67, was admitted to hospital on Feb. 14, 1923, complaining of intermittent pain in the belly of an acute character, retching, and inability to pass flatus. The attack had come on suddenly in the early hours of the morning of Feb. 12, waking him up. He took castor oil, which brought no relief, but at that time he only thought that he was suffering from one of the numerous bilious attacks to which he had been accustomed for the last twenty years. He sent for his doctor, who saw him the same day and advised his admission to hospital, as he had passed no flatus and definite small-intestine peristalsis was evident; there was no rigidity or tenderness.

EXAMINATION.—On arrival at hospital the patient showed the following clinical condition: He was wearing an anxious expression, but trying to hide it. Pulse 72, temperature 99·2°. Tongue dry and coated with a thick brownish fur. Arteriosclerosis present, but no organic disease discernible in the heart, lungs, or kidneys; urine normal. Rectal examination revealed a rectum full of fæces. The bowels had not been moved for two days. Examination of the abdomen showed well-marked small-intestine peristalsis, but no rigidity or tenderness was noted.

TREATMENT.—An oil and turpentine enema was given which emptied the lower bowel, but no flatus was passed. A dose of morphine, gr. $\frac{1}{4}$, was injected and a large poultice applied to the abdomen. At the end of four hours there was no alteration either way, so he was given a good dose of castor oil. This increased the peristalsis and caused some pain, but no flatus was passed.

DIAGNOSIS.—Acute intestinal obstruction of which the cause could not be ascertained.

OPERATION.—Eight hours after admission the abdomen was opened in the mid-line, and as no particularly distended or collapsed gut was seen, the large bowel was first traced from cæcum to rectum without any obstruction being found. Then the small bowel was followed backwards from the ileo-cæcal valve, and about ten feet from the valve a foot of bowel was noticed to be anæmic, and reacted sluggishly to stimulation. As there was nothing at the time to account for this it was passed over. No distention of the gut above this area, and no collapse below it, were noted. About four feet from the duodeno-jejunal junction the sacculated condition of the bowel shown in *Fig.* 260 was encountered, and traced to the duodenojejunal junction, where the most marked sacculation was discovered. As there was no sign of inflammation in any of the sacculi, and all were empty, nothing further was done and the abdomen was closed.

FIG. 260.—Sacculitis of jejunum.

AFTER-PROGRESS.—On Feb. 16, the bowels were well moved by means of an ordinary enema, with the passage of flatus, and the patient appeared comfortable. Liquid paraffin was given night and morning. On Feb. 18 his temperature commenced to rise, the abdomen showed increasing distention, and was ridged with marked small-intestine peristalsis. Oil and turpentine enemata had no effect. The tongue was dry. Signs of pneumonia were evident at the right base. Death occurred on Feb. 19.

POST-MORTEM.—On opening the abdomen, the piece of bowel which had been observed during the operation to be anæmic and sluggish to stimulation was found lying gangrenous. A small embolus of the mesenteric artery supplying the segment was found. The bowel above the gangrenous loop was now markedly distended. The middle cusp of the aortic valve showed a definite hard excrescence about the size of a split pea, with roughened edges. Aortitis was present in a fairly well-marked degree. There was pneumonia of the right lower lobe in a badly adherent lung. The left kidney showed a large cyst (size of Tangerine orange) at the lower pole, and studded throughout the substance were numerous small infarcts. The right kidney appeared more healthy, with fewer infarcts. The liver was friable, but showed no macroscopic pathology.

The section of the small bowel in which the sacculi were present was

removed, blown up, and sent in a sealed tin to Professor Saint, of Cape Town University, for a pathological report and preservation of the specimen.

Report.—The specimen (*Fig.* 260) consists of the upper jejunum, immediately below the duodenojejunal flexure, 100 cm. long. All along the mesenteric border of the gut are seen sacculi of varying size. The largest is about 6 cm. in diameter, the average about 1·5 cm. and the smallest just visible. The largest are situated in the upper portion of the gut. All the sacculi are situated in the region of the mesenteric attachment, and a large number are alongside vessels which are running into the bowel wall. Those which do not bulge into the mesentery appear to be at points where vessels are perforating the wall. The mouths of the sacculi are very wide. There is no sign of inflammation in any of them, and no concretions are present in them.

Microscopic Report of Small Sacculus (Professor BARTLETT, Cape Town University).—The mucosa bulges through a wide breach in the muscle coats, apparently at the point where large arteries and veins pierce them. The walls of the sacculi are thus composed of mucosa, submucosa, and serosa.

COMMENTARY, BY PROFESSOR SAINT.

The Acute Intestinal Obstruction.—Embolism of the mesenteric vessels is not common, but one cannot regard it as rare, and cases of this type are encountered from time to time. Usually the obstruction is not complete, and flatus continues to be passed. Blood-stained diarrhœa, too, is not infrequent.

In the present case, with complete obstruction, no physical signs of endocarditis were observed either before or after operation, and no diagnosis of the cause of the obstruction was made. The anæmic condition of the affected loop of gut and its diminished contractility were commented on at the time of operation, but its condition was not outstanding enough to command a detailed examination, and it was not credited with being the cause of the obstruction. This was accounted for by the absence of any marked difference in the bowel above and below the loop, which is somewhat surprising in view of the exaggerated degree of visible peristalsis present before operation. Otherwise, no doubt, the absence of pulsation in the vessels supplying the loop would have been noted and the cause thereby diagnosed.

The exaggerated visible peristalsis is worthy of mention, as some surgeons emphatically deny its occurrence in acute intestinal obstruction. If carefully looked for, it will usually be seen, though not in so marked a degree as in the case described above.

The Sacculated Condition of the Jejunum.—This condition is always interesting, and is especially so in the present case. One is usually accustomed to associate with the development of sacculi in any of the hollow muscular systems—(1) obstruction, with a resultant increase in the intravisceral tension, and (2) a weak spot in the wall. The weak places in the wall may be either congenital or acquired, the congenital being usually at situations where some structure pierces the wall—e.g., blood-vessels, or the ureter in the urinary bladder—while the acquired are usually the result of some destruction of the outer walls either by injury or inflammation. Where the weak spot is congenital, and is due, as it mostly is, to the perforation of the wall by a

blood-vessel, the commonest type of sacculus is found, and consists of a protrusion of the inner coat through the outer coats, so that the muscular coat particularly is not represented in its wall. This is the usual sacculus of the mucus-lined hollow muscular systems. Where the weak spot is acquired, and is due to destruction of the outer coats by injury or inflammation, the inner lining bulges outwards, and the muscular coat may at first be represented in the wall, deficient it is true, but still there, though later it is entirely absent. This is more particularly seen in the vascular system, in aneurysm of the big vessels. In the vascular system, no obstruction or increased tension is necessary, if the weak spot be present, as the normal blood-pressure is sufficient to produce bulging.

" Sacculi are never of congenital origin, and have consequently not been (*rarely been*)* found in youth; they are associated with obstruction of the outlet, and weakness of the wall, of the affected viscus; they are multiple; they are thin-walled, because they are mostly hernias of the inner (mucous or endothelial) coat through the muscular coat; they are rounded in shape; they do not (usually) attain to very large size; and they are practically limited to advanced life. In the urinary bladder, all parts of the gastro-intestinal tract, the gall-bladder, the vermiform appendix, and Fallopian tubes, similar swellings have been described; indeed it is safe to say that they will be found, if sought for, in any of the hollow muscular-coated viscera " (Rutherford Morison).

Common to all sacculi, in view of their mode of origin, are: (1) *Reducibility* of the contents into the parent cavity; and (2) *An expansile impulse* in the sacculus on increase of pressure in the parent cavity. Where these can be elicited, they constitute pathognomonic signs of the condition: they are of chief importance in the case of aneurysms. Other sacculi are usually too deeply situated to be examined except where exposed by surgical operation.

Rutherford Morison has further emphasized the liability of sacculi to the same pathological processes as occur in the appendix and other diverticula. All of them may harbour concretions, and all of them are liable to infection by micro-organisms and attacks of inflammation, while the terminations of the inflammation differ in no way from what is found in the appendix.

From the clinical data of the case reported above, it is obvious that there was no evidence of any obstruction having been present previous to the acute one under consideration, which was of a few days' duration only. One must therefore conclude that the ordinary intravisceral tension had been sufficient to produce the bulgings. Under these circumstances one is inclined to accept the probability that the intestinal wall was defective, in so far as the normal weak spots in it, where the vessels perforate the muscular coat, were larger than normal. This is borne out by dissection of the gut. The sacculi, as described, were of the common type, and occupied the favourite portion of the small bowel when they occur in it, viz., the proximal part of the jejunum.

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* The italics are mine.

In comparison with this case, one might quote that of a lady in whom one was asked to undo a gastro-enterostomy performed four years previously for a duodenal ulcer. The patient was relieved for two years, and then began to have a great deal of pain after food, etc., suggesting the possibility of a gastrojejunal ulcer. At operation, the jejunum was found to be twisted on itself at the anastomosis, giving rise to considerable obstruction in the small proximal loop. In this dilated and hypertrophied loop a single sacculus, the size of a pea, was present. No detail of its exact relations could be noted, except that it was slightly to the side of the mesenteric attachment. It was infolded by Lembert sutures. In this situation a sacculus of such a type is by no means common.

Before leaving the subject, one feels one ought to register a word of censure against the use of the term diverticulum to describe these bulgings. It is one example of what appears to be an inherent weakness of the profession, apparently hereditary, to use either the same word to describe quite different pathological conditions, or different words to describe the same pathological condition. As opposed to sacculi, diverticula are of congenital origin; all the coats of the affected viscus or hollow muscular system enter into the composition of their wall; all have a special vascular supply of their own; they are seldom, if ever, multiple; and they are found at any age. The use of the term sacculus to describe these acquired bulgings through the walls of the hollow muscular systems, which ought to include aneurysms, is simpler and clearer than the ungainly terms 'false' or 'acquired' diverticula; this is more especially the case when inflammation has arisen, for in such an event the term 'diverticulitis' is used alone, and one is left to guess whether the congenital or acquired bulgings are being discussed.

RARE LESION OF UPPER END OF FEMUR: FRACTURE OF HEAD OR SEPARATION OF EPIPHYSIS.

By JOSEPH J. LEVIN, Johannesburg.

Fracture of the head of the femur or separation of the upper epiphysis is of sufficient rarity, I think, to justify publication of the following case. The history, for which I am indebted to Dr. H. Q. F. Thompson, who treated the case during life, is as follows:—

"Namadi Nyambaan, a native, 33 years old, employed underground in a mine, was admitted to hospital on Jan. 2, 1923, for an injury to the right hip caused the previous day by a blow from a truck (? cocopan). He stated that he did not fall down nor was he jammed against anything. He continued to work. That same night his right leg was painful, and he reported to the dressing station next day. On admission, the patient walked with a limp. Examination revealed no abnormality about the right femur or hip-joint. There was no swelling or shortening, but there was definite tenderness on pressure over the ilium. There was no wound or abrasion. It was thought

that he probably had a contusion of the ilium. He was kept in bed, and a lead and opium dressing was placed over the right buttock.

"PROGRESS.—*Jan.* 7. Patient got out of bed and walked about, though still with a limp. This limp, instead of improving with exercise, became more pronounced, and on Jan. 24 patient remained in bed. On Jan. 28 he was X-rayed, but no abnormality detected. Patient did not get up, and complained of pain in his right buttock. He always placed his finger on one point where he said the pain was worst. This point corresponded with the hip-joint. There was no swelling to be seen. Patient then began gradually to flex his legs, and would lie in bed with his knees under his chin. He never lay on his back, but preferred the right side.

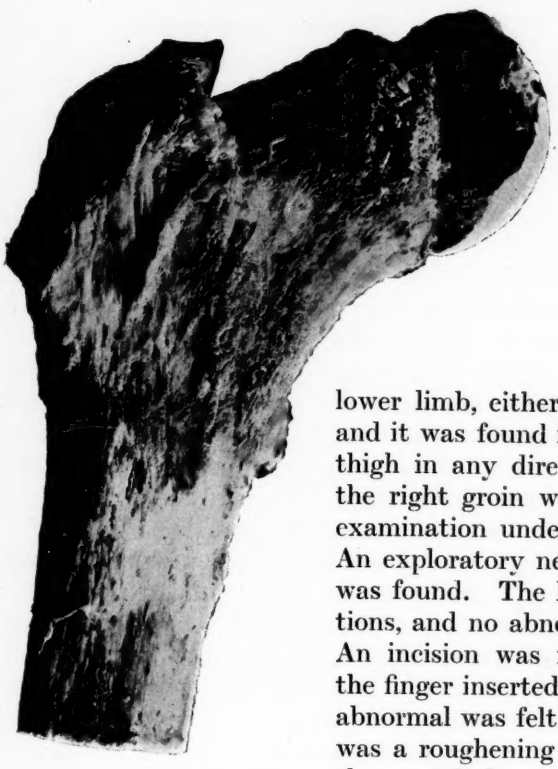

FIG. 261.—Fracture of head of femur.

"*Feb.* 17. His temperature rose to 101·6°, and the next day an exploratory needle was inserted through the right buttock down to the hip-joint and in several directions, but no pus was found. (*Patient's mouth and gums were in a very bad condition.*)

"Two days later he was unable to extend the right lower limb, either at the hip-joint or at the knee, and it was found impossible to rotate or move the thigh in any direction. A certain fullness about the right groin was noticed, and on Feb. 21 an examination under an anæsthetic was performed. An exploratory needle was again used, but no pus was found. The limb moved freely in all directions, and no abnormality of any sort was noticed. An incision was made in the right buttock and the finger inserted down to the hip-joint. Nothing abnormal was felt there, but I imagined that there was a roughening of the ilium above the ridge of the acetabulum. A drain was inserted into the wound, though no pus had been found. The right lower limb was fixed on a back splint from about the middle of the thigh down—an ordinary back splint with a foot-piece.

"*Feb.* 22. The right lower limb was put on extension by means of strapping and weights, from about the middle of the thigh. During the next three days the temperature was high, and the wound clean. No complaint of pain was made, but on Feb. 26 pus began to appear from the wound and drained freely.

"*March* 5. Patient dislocated his jaw; this was reduced under a general anæsthetic. Patient died at 9.40 a.m. the day following."

The points in the history to which I would draw special attention are: (1) That when the patient 'walked about' on Jan. 7, the limp became more

pronounced; (2) That the patient's mouth and gums were in a 'bad condition'; (3) That an exploratory needle was used on two occasions, and that an incision was made over the buttock; (4) That an X-ray photograph was taken, but revealed no fracture.

On March 7 I made a post-mortem examination, and found a septic incised wound in the right buttock. On investigating the hip-joint, I found the head of the bone in the acetabulum separated from the neck and shaft—in fact, what I considered an ununited fracture of the head of the femur, the line of fracture being clearly indicated in the photograph of the specimen shown in *Fig.* 261. The joint was very septic and contained green stinking pus. The buttock was very septic. I gave as the cause of death: Fracture of the femur (head)—ununited. Sepsis in hip-joint and buttock. Septic absorption.

The points for discussion seem to me to be: (1) Was this a fracture of the head of the femur, or was it a separation of the epiphysis? (2) Did the fracture or the separation occur on the first of January, or was the lesion due to scurvy alone? (3) Was it the end-result of local sepsis, sepsis in the mouth, or scurvy, superadded to a minor injury in the region of the hip-joint?

1. If this were a separated epiphysis, one would have expected it to have followed the normal line of the junction of the epiphysis with the diaphysis, but examination of the specimen shows that this separation of head from neck is at a higher level than the epiphyseal line, although posteriorly it does for a short distance coincide with it. Further, the age of the patient—33—is against a separation of the epiphysis. The head of the femur fuses with the shaft between the ages of 18 and 20. I am therefore of opinion that this was not a separated epiphysis but a fracture. In this the pathologists at the South African Institute for Medical Research agree with me.

2. The question as to whether this fracture occurred on Jan. 1 as a complete fracture is very difficult to decide. If so, then it is difficult to understand how the boy was able to walk. It seems possible that the boy received an injury on that date which partially fractured the head of the bone and did little or no damage to the capsule of the joint. One can conceive of such an injury being painful, yet not preventing the patient from moving about—though with difficulty. Subsequently on Jan. 7 the boy got out of bed and walked about till Jan. 24, and the notes say that the limp became more pronounced; probably, owing to the effort of getting up and walking about from Jan. 7 to Jan. 24, the bone may have been completely fractured. Against this opinion is the fact that the patient was X-rayed on Jan. 28 but no abnormality was detected. Radiologists, however, are not always successful in their photographic efforts, and this X-ray photograph—which I have seen—is admittedly not a good one; and although even in the best of light one cannot see any fracture, yet it seems to be possible that there may have been one.

In view, however, of the fact that the notes state that the patient's mouth and gums were in a very bad condition (Dr. Thompson informs me that they showed evidence of scurvy), for which reason the boy was put on to an anti-scorbutic diet, the question arises as to whether this was not a spontaneous fracture, subsequent to Jan. 28, due to scurvy alone. Hess[1] favours this

possibility; it would be impertinence therefore on my part to doubt that such lesions could occur. But while scurvy is very common on the reef amongst the mine boys, yet one has not heard before of such a lesion occurring amongst them, and therefore one is inclined to question this being a fracture due to scurvy. Examination of the specimen affords no help, owing to the presence of advanced sepsis.

3. I am informed by Dr. Orenstein, Superintendent of Sanitation, Rand Mines Ltd., that it is rare to find spongy and swollen gums amongst the mine natives due to scurvy uncomplicated by pyorrhœa; the two seem nearly always to be indistinguishably combined, and therefore one is bound to consider the remote influence of the condition of the boy's mouth in its relation to the original injury, which leads us to the third alternative, namely, that the boy received a minor injury on Jan. 1, and owing to the septic and scorbutic condition of his mouth he developed an arthritis of the hip-joint, which became septic. That this is possible there is no denying, and it is confirmed by Douglas Knocker.[2]

There is also the possibility—and I say this with diffidence—that sepsis may have developed in the joint owing to the two explorations with a needle, or the incision which was made over the buttock.

Fracture of the head of the femur (or, for that matter, separation of the epiphysis) is notoriously a very rare occurrence.

I nevertheless diffidently express the opinion that this boy—as the result of the injury on Jan. 1—fractured the head of his femur, and that subsequently, owing to the septic and scorbutic condition of his mouth, or to sepsis accidentally introduced locally, he developed a septic arthritis of his hip-joint, which prevented the fracture from uniting, and which ultimately caused his death.

REFERENCES.

[1] HESS, *Scurvy Past and Present.*
[2] KNOCKER, DOUGLAS, *Accidents in their Medico-Legal Aspect*, 1910, 501.

REVIEWS AND NOTICES OF BOOKS.

A System of Surgery. Edited by C. C. Choyce, F.R.C.S., Director of the Surgical Unit, University College, London, and J. Martin Beattie, M.D., Professor of Bacteriology, University of Liverpool. In three volumes. Second edition. Vol. I, pp. 1013, with 19 coloured plates, 58 half-tone plates, and 245 figures in the text. Vol. II, pp. 1057, with 20 coloured plates, 10 half-tone plates, and 226 figures in the text. Vol. III, pp. 1176, with 11 coloured plates, 30 half-tone plates, and 329 figures in the text. London: Cassell & Co. Ltd. £6.

The second edition of this important work was in course of preparation in 1914, but its appearance had to be postponed until after the war. This delay, however, has been more than compensated for by the care spent on the present edition and the well-balanced attention given to the various subjects treated. Not only have all the articles been revised, re-written, and brought up to date, but in some sections new authors have contributed to the work. These are Mr. Magnus Redding on X-ray diagnosis, Mr. Hey Groves on fractures, Colonel Harrison on syphilis, Colonel West on tetanus, Mr. Norman Patterson on the diseases of the throat, and Mr. Trethowan on orthopædic surgery. There are upwards of 150 new illustrations, including 50 new plates.

Volume I deals with surgical bacteriology (Dreyer) and its therapeutic applications (Eyre), inflammation (Beattie and Maynard Smith), suppuration (Lenthal Cheatle), ulceration (Pannett), gangrene (Nitch), wounds (Choyce), burns and scalds (Woodward), constitutional results of trauma (Russell Howard), toxæmia, septicæmia, and pyæmia (Martin), tumours (Raymond Johnson), examination of the blood and cerebrospinal fluid (Beattie), X-ray diagnosis (Magnus Redding), general anæsthesia (Blomfield), local anæsthesia (Gwynne Williams), spinal anæsthesia (McGavin), tuberculosis (Beattie), syphilis (Harrison), venereal diseases other than syphilis (Leedham-Green), certain tropical diseases (Daniels and Low), glanders (Rock Carling), actinomycosis (Choyce), tetanus (West), hydrophobia (Calmette), anthrax (Turner), diseases caused by animal parasites (Madden).

All of these articles are well illustrated, practical, and up to date. Those which specially attract attention are the chapters on practical bacteriology and blood examination by Beattie; on gangrene by Nitch, who gives a good account of modern methods of treatment, e.g., division of the sympathetic; on tumours by Raymond Johnson, who has selected a remarkably good series of illustrations; on X-ray diagnosis by Magnus Redding; and the chapter on syphilis by Harrison.

Volume II contains the following articles: The breast (Sampson Handley), the spleen (Gordon-Watson), face, lips, and palate (Nitch), tongue (Clayton-Greene), salivary glands (Ivor Back), œsophagus (Rigby), stomach and duodenum (Sherren), intestines (Alex. Miles), appendix and peritoneum (Sargent), hernia (McGavin), rectum (Clogg), liver, gall-bladder, and pancreas (Grey Turner), urinary organs (Thomson-Walker), male genital organs (Russell Howard).

Handley's chapters on the breast give a thorough account of his work on permeation, including his recent views about Paget's disease of the nipple. There is also a detailed description of the operative and post-operative treatment which is of great practical value. Prophylactic X-ray treatment is to be applied to every case after operation. Radium tubes are buried for twenty-four hours in the intercostal spaces and in the supraclavicular fossa. Open-air treatment for some months is strongly urged.

Nitch's article on cleft palate is a model of clear description and illustration. He holds the balance almost evenly between the early flap operation and the later operation by direct suture, but he definitely states that the second month of life is the time of choice.

Clayton-Greene, writing on cancer of the tongue, expresses the generally accepted pessimism about methods of treatment and results. In regard to cutting operations, he urges the necessity of removing the tongue muscles down to the hyoid bone. The method of primary removal of glands from the neck, followed by diathermy to the tongue, is that recommended.

Sherren's article on the stomach and duodenum is marked by his clear exposition and discussion, especially in relation to the diagnosis and treatment of gastric ulcer and cancer. He holds that for a 'free' gastric ulcer, gastro-enterostomy is an efficient treatment, and he would reserve partial gastrectomy for cases of adherent or indurated ulcers.

Other notable articles in this volume are those by Miles on the intestines, Grey Turner on the gall-bladder and pancreas, and Thomson-Walker on the urinary organs. Space forbids these being described in any detail.

Volume III contains the following articles: Female genital organs (Bonney), cardiovascular system (Rock Carling), lymphatics (Dobson), neck (Edmunds), nose (Barwell), throat and ear (Patterson), œsophagoscopy and bronchoscopy (StClair Thomson), lungs and pleura (Morriston Davies), nerves (Sherren), skull and brain, spine and spinal cord (Trotter), jaws (Fitzwilliams), skin (Legg), muscles (Rock Carling), bursæ (Telford), diseases of bones and joints (Choyce), fractures (Hey Groves), orthopædic surgery (Trethowan). This volume is largely concerned with 'special departments' of surgery, and must have caused the editors much care and anxiety in allowing as much as is necessary for a work of this kind, without making it too long.

Trotter's articles on the brain and spinal cord are remarkably interesting and suggestive, because they deal so well with general principles without being overburdened with detail.

Choyce, too, in taking the large subject of bones and joints, writes very clearly and dogmatically as a teacher speaking to students, and he has included all the essentials of these subjects in a comparatively small space. This has been rendered easier for him by the fact that special sections on fractures and on deformities cover much of the ground of bone and joint surgery.

Hey Groves, in writing of fractures, deals chiefly with the principles underlying various methods of treatment, e.g., those by fixed splinting, early mobilization, traction, open operation, and bone-grafting.

Trethowan writes on the surgery of deformities, and his article is fresh without being heterodox. It is evident that he has had difficulty in keeping to his allotted space, as so much of his article has been relegated to small print.

The work as a whole, as well as in detail, is a good representation of present-day British surgery, and as such it stands to-day without a rival. The publishers, as well as the editors, are to be congratulated on the way in which the book is arranged, printed, and illustrated. The coloured plates are numerous and beautiful, whilst the half-tone plates and other illustrations are clear and well chosen.

Die Willkürlich bewegbare künstliche Hand. By PROFESSORS F. SAUERBRUCH and C. TEN HORN, Universitätsklinik, Munich. Vol. II. Royal 8vo. Pp. 249 + iv, with 230 illustrations, part in colour. 1923. Berlin: Julius Springer. Unbound, 11s. 8d. Bound, 12s. 11d.

THE proposals of the Italian Vanghetti to utilize the muscles of a stump for the movements of the fingers of an artificial hand were by no one taken up with such zeal and energy as by the German surgeon Sauerbruch. But while Vanghetti devised many methods of achieving his end, Sauerbruch confined himself to one alone, namely, the tunnel or canalization method. The technique which he employed

was an adaptation to local circumstances of Rochet's operation of urethroplasty. This procedure and its results were the subjects in 1916 of *Die Willkürlich bewegbare künstliche Hand*, in which Sauerbruch recommended his operation. Of this book the work now under notice forms the second volume. In the interval, cinematization has been tried in most of the lately belligerent countries, but the results have been generally disappointing, no matter whether Sauerbruch's or other procedures have been employed, and we believe that we can safely assert that it has been practically abandoned, much to the disappointment of those surgeons who had enthusiastically welcomed the innovotion. It was found in this country that there were two great obstacles in the way of success. One of these was the lack of sufficient power in the muscular 'motors', and the other was the difficulty of fitting a satisfactory prosthesis, despite many experiments which were made on behalf of the Ministry of Pensions.

Professor Sauerbruch now describes the latest improvements in the technique of the operation, and emphatically reasserts his claims that it is a practical success when it is performed in suitable cases with due consideration of all details, and when such prostheses as he describes are used.

It seems to us clear that on the evidence brought forward there are a certain number of cases in which success has been attained, but only after long and careful training and with very accurately adjusted appliances, and that other surgeons in Germany have not formed nearly such favourable opinions of the procedure as those that are held by Sauerbruch and his school. It is, we think, to be regretted that the comparative isolation of Germany in general, and of Bavaria in particular, has prevented the surgical world from testing for itself the actual worth of the method by investigation on the spot, and we hope that it will not be long before such an inquiry is made. In the meantime, if any British surgeon is tempted to cinematize an amputation-stump by the tunnel method, he could not have a better guide than this volume, in which every detail is discussed and profusely illustrated, both as regards the amputation-stump and the various types of prosthesis suitable for it.

Orthopædic Surgery. By Sir Robert Jones, K.B.E., C.B., Director of Orthopædic Surgery, St. Thomas's Hospital; Lecturer on Orthopædic Surgery, Liverpool University; and Robert Lovett, M.D., F.A.C.S., John B. and Buckmaster Brown Professor of Orthopedic Surgery in Harvard University. Pp. 699, with 712 engravings. 1923. London: Oxford Medical Publications, Henry Frowde and Hodder & Stoughton. 42s. net.

The reputation of both the authors of this book is so great that a joint work from their pens is assured of a warm welcome from general surgeons as well as from those who have specialized in orthopædics. In the preface the authors explain their dissatisfaction with the title of their work—a title adopted for want of a better—because they believe "that the principles governing the diagnosis and treatment of these conditions should be those, and only those, embodied in general surgery".

The general arrangement of a book on orthopædic surgery is always a matter of difficulty; we think the authors have been wise in beginning with the anatomy, physiology, and general pathology of joints, and then passing on to the traumatic affections of joints. A description of the anatomy of the individual joints precedes each section and will be found useful to the student. These chapters embody the authors' views, which are for the most part well known from their previous writings, but are enriched by numerous little hints which their enormous experience enables them to give. We must, however, confess to disappointment with the section on coxa vara; it leaves us with no clear idea as to their views on the nature and treatment of that well-defined class called infantile or cervical coxa vara.

On the vexed question as to the existence of an affection worthy of the title of 'osteochondritis desiccans' the authors are definitely on the side of those who

believe trauma to be responsible in the great majority of cases. The chapter on "Stiffness of the joints—Adhesions and Ankylosis" is full of sound instruction. Tuberculosis of the joints and spine is very fully dealt with in five excellent chapters. Every question is discussed with the minutest care, the reasons for every detail of treatment being carefully explained.

In these chapters, as elsewhere throughout the book, whenever the authors are not in entire agreement on a particular point, each has stated his own opinion and added his initials. Similarly, when the general practice in dealing with a particular affection in America differs from that favoured by surgeons in this country, both methods of treatment are given.

One or two points in these chapters call for comment. For instance, surprise will, we think, be caused by the advice that when a cold abscess threatens to burst, a small incision, half an inch in length, should be made in it, and a drain inserted for not longer than twenty-four hours, the dressings being changed as infrequently as possible. It is true that the authors insist on the necessity for the most scrupulous care in the subsequent dressing of the wound, and say, "the surgeon who cannot provide this should let abscesses alone".

We must confess regret at the inclusion of an illustration and description of a *single* Thomas hip-splint. Certainly it is stated that it is used, by one of the authors, only when disease in the hip-joint is quiescent and ambulatory treatment has begun; but it is a splint with which it is difficult or impossible to prevent deformity, particularly in the form in which the splint is usually and incorrectly made; moreover, it is one which is regarded by some—wrongly, we think—as an efficient means of treating arthritis. In the section on tuberculosis of the shoulder-joint illustrations are given of treatment in plaster-of-Paris with the arm abducted and apparently externally rotated to the full extent at the shoulder: this surely is a mistake, as the positions illustrated do not agree with those described in the text as being the best, and generally accepted as such, when ankylosis of the joint is expected or feared. Excision of the ankle by the transverse incision to which Ochsner's name is attached in the book does not seem to differ materially from the method of Hüter, though even the latter was not by any means the first surgeon to practise it.

Most of the other diseases of bones and joints are fully dealt with in a series of chapters. A section is given to muscle and bone atrophy, and another, particularly clear and instructive, deals with functional contractions and deformities. Spastic paralysis has a chapter to itself—one of the best in the book. The various methods of treatment of this affection are dealt with in a particularly clear manner. The authors leave the reader in no doubt as to their preference for the older methods of attacking the spastic muscles directly by tenotomy and exsection of muscle, though detailed descriptions of the Stöffel and other methods are given.

Poliomyelitis is, of course, dealt with exhaustively. The avoidance of over-fatigue of muscles recovering from paralysis is rightly insisted upon as of prime importance. The operative measures available when further recovery is not expected are dealt with in a clear manner, the pages being plentifully supplied with useful illustrations. The remaining chapters deal with obstetric paralysis, congenital deformities, torticollis, club-foot, etc.

In the discussion of obstetric paralysis there is no definite statement that posterior displacement of the head of the humerus is a common late result of this affection, yet the existence of such is admitted in the reference to operations designed by other surgeons for its relief. In so-called congenital torticollis the authors—we think rightly—favour division of the sternomastoid and surrounding fascia by the open method, and condemn subcutaneous tenotomy. The last chapter is devoted to scoliosis, the subject, of course, of the excellent monograph first published some years ago by one of the authors.

Practically every affection which one might expect to find is included in the book; Dupuytren's contraction is, however, a noticeable exception. The book contains such a wealth of information and sound advice, as was only to be expected, that the reader's attention is rather caught by certain imperfections, one or two

of which have been referred to. No doubt improvements will be made here and there in the next edition, which will certainly be called for before very long. We noticed rather an unusual number of printer's errors. The illustrations are numerous and in every way worthy of the book, which will certainly be read by a very large number of surgeons and students.

Die ersten 25 Jahre der Deutschen Gesellschaft für Chirugie: ein Beitrag zur Geschichte der Chirurgie. By FRIEDRICH TRENDELENBURG. Demy 8vo. Pp. 467. 1923. Berlin: Julius Springer. 10s.

UNDER the title "The First Twenty-five years of the German Society of Surgery", Professor Trendelenburg, one of four surviving original members, has classified in more than sixty chapters the proceedings of the society between the years 1872 and 1899. As the second part of the title indicates, he has made it a contribution to the history of surgery, particularly, be it remarked, from a German point of view. From the book may be learnt how it came about that, whereas at the London Congress in 1881 the leadership seemed to be with British surgery, at the Berlin Congress in 1890 German surgery had taken the lead over all countries.

Lister's procedure, inspired by Pasteur, had reached its acme of fame at the London Congress; it had rendered possible the successful treatment of conditions for which operations, when undertaken at all, had formerly been risky ventures. Moreover, successful experiments on animals could be likewise carried out under antisepsis and anæsthesia, which thus directed the way to new operations. An opponent of Listerism had used the jangle of words, "the ritualism of Listerism"; by so doing he directed attention to Lister's eternal merit—that of bringing into surgery *a* ritual in place of slapdash improvisations. In future the medical student and nurse-probationer learnt that surgery demanded a procedure methodical in detail. An exponent of Listerism seemed to consider Lister's particular procedures as *the* ritual, as if it were a fixed and permanent dogma. By it Spencer Wells had reduced the mortality following ovariotomy; but for abdominal surgery in general part of Lister's method was unsuitable, and to this English ovariotomists offered only negative criticism. Koch and his pupils cultivated bacteria on solid media, identified them by staining, and proved the efficiency of steam under pressure to destroy them. With all German persistency and diligence such men as Neuber, of Kiel, and Schimmelbusch, assistant to Bergmann, in Berlin, sought out the infective agents of wounds, whether on the skin of the patient or on the surgeon's hands and instruments, and new ways of sterilizing sources of infection without doing harm. At the same time the air was demonstrated not to be such an important source of infection. From the demonstration given by Schimmelbusch at the Berlin Congress in 1890 dates the gradual supersession of the so-called 'antiseptic' by the 'aseptic' method.

Before 1872 German surgeons had had only one possible opportunity of meeting—namely, at the Surgical Section of the Naturforscher's Versammlung held at various places. By the see-saw of history the Germans were once again the conquerors; they had united themselves into the Reich with Berlin as the capital; they had received a large indemnity in cash, also territory in the Rhineland—which was to undergo transformation from the condition described in *Childe Harold*—and money was forthcoming for the rebuilding of hospitals and the establishment of institutions for research.

The principal founders of the society were Bernhard Langenbeck, nephew of Konrad Langenbeck, of Göttingen, and known for his cleft-palate and pharynx operations; Gustav Simon, of Heidelberg, the experimenter and operator on the spleen and kidney; Richard Volkmann, of Halle, who extended the English observations on chimney-sweep's cancer to tar cancer, and described the ischæmic contracture of the forearm; Victor Bruns, of Tübingen, the first to remove a polypus from the larynx in the case of his brother; Gurlt, the author of the unique history of surgery before the study of human anatomy; Esmarch, of Kiel, the advocate

of first-aid in both war and peace. The first treasurer was Professor Trendelenburg, then assistant to Langenbeck; he had previously in 1869 invented his tamponade cannula, and later, in 1881, first employed his raised pelvis position when operating for a vesicovaginal fistula across the bladder, next when removing polypi from the bladder.

It was some years before a regular place of meeting could be founded, when, in conjunction with the Berlin Medical Society, Langenbeck-Virchow House and Library arose. A few non-German surgeons attended: William MacCormac was an original foreign member; the one survivor, Sir Alexander Ogston, contributed in 1877 an account of his operation for genu valgum, and in 1880 described the staphylococci invariably present in acute abscesses; at the first meeting Jonathan Hutchinson described his successful operation for intussusception; Paget and Spencer Wells were made honorary members in 1885; Victor Horsley made contributions on thyroid and brain surgery; and Arthur Barker was often present. The only Frenchman to attend, Doyen, in 1895 and 1898, concerned himself with his cinema demonstrations, and attacked his fellow-countryman, Péan, about the piecemeal removal of the uterus. Among Americans, Senn, Murphy, and Roswell Park were present at meetings. There was a laughable hitch in Senn's demonstation of his method for locating intestinal obstruction when it was found that the hydrogen was being passed into the wrong orifice. The following may be selected as great advances made in Germany during the period under review.

After renewed experiments on animals, using antisepsis and anæsthesia, by Wöffler, Czerny, Winiwarter, and others, Billroth, of Vienna, commenced his operations for cancer of the stomach, Winiwarter that of anterior gastrojejunostomy, Hacker the posterior operation, and Mickulicz, of Breslau, the practice of operating at once for a perforation.

General anæsthesia never attained marked success because of the lack of special anæsthetists who could instruct medical students. Instead Schleich, Braun, and Bier directed attention to local, regional, and spinal anæsthesia, Röntgen, of Würzburg, adapted advances made in physics to practical surgery, and Kümmell, of Hamburg, demonstrated the use of the discovery for the diagnosis of injuries to the skeleton.

Fehleisen in 1882, starting to inquire into the influence which an attack of erysipelas appeared to exert sometimes upon the course of lupus and sarcoma, identified the streptococcus, and this original idea was followed up by Dr. Coley from 1895 onwards.

The grave operation of excision of the larynx was taken up by Billroth in 1874, and Gluck proposed the preliminary division of the trachea, but the results were unfavourable. Rose, under the title 'bronchectomie', later known as 'thyrotomy' or 'laryngo-fissure', proposed the more limited operation which Hahn in Berlin and Butlin and Semon in this country rendered a success. However, when the case of the Emperor Frederick arose, it was the larger dangerous operation which was proposed and rejected.

To make the author's 'Beitrag' into a real history of the period would require an extended account of the work of surgeons in other countries.

Chirurgie des Voies Biliaires. By HENRI HARTMANN and Associates. Fifth edition. Imperial 8vo. Pp. 356, with 89 illustrations. 1923. Paris: Masson et Cie. 30 fr.

THIS is the fifth edition of the book; the last was produced before the great war. Hartmann leads off with a chapter giving the relative frequency of all kinds of operations performed at l'Hôpital Bichat in a series of 3062, and the cause of death in each of the 166 fatal cases in the series. The next chapter, by Maurice Virenque, deals with some rather unusual and abstruse points in the naked-eye anatomy of the gall-bladder, and the effects of various curvatures of the gall-bladder, which he describes, on the pathology of the organ. Some account is given of the normal

and abnormal vascular supply, but we think that the importance of this from the surgical point of view is not sufficiently recognized; there is nothing said about the anatomy of the bile-ducts, and the frequent variations in these structures are not mentioned, though their importance to the surgeon cannot be too strongly emphasized. The author of this section devotes some space to a description of the ligaments of the gall-bladder; he considers the cysticoduodenal of embryological origin, whereas the cysticocolic is only found as a result of pericholecystitis.

The greater part of the book is taken up with the consideration of the various types of cholecystitis. Inflammation of the gall-bladder is regarded as *the* important disease, gall-stones being merely an incident in the biology of this lesion. We think that most surgeons are in agreement on this point. Hartmann is responsible for Chapters III and IV, in which the pathogenesis and clinical aspects of cholecystitis and gall-stones are discussed. Though the subject is very clearly and fully set out, the conclusions do not differ materially from those held by most authors of note—namely, that the gall-bladder is primarily infected from the blood, and that infection of the tracts with *B. coli* is a secondary affair, the cholecystitis having opened the way by causing stasis of bile. The whole of this article is excellently illustrated by the recital of cases to bring out the essential points under discussion. However, there is nothing new.

Chapter V, by Maurice Renaud, is concerned with the biological and pathological study of cholecystitis, which according to him is always an acute infection in the first place, the sequelæ appearing when infection continues in an attenuated form. A series of thirty-four plates illustrates better than any description the sequence of events from the acute infection to the final stages of sclerosis of the gall-bladder and surrounding tissues with involvement of adjacent organs. These plates provide one of the best features of the book.

In Chapter VI, Hautefort reviews the results of experimental ablation of the gall-bladder. He claims to have shown that any stump of the cystic duct which may be left between the ligature and the common duct after cholecystectomy will dilate and form a new, though small, gall-bladder in which bile will accumulate; also that all the extra-hepatic ducts share in this dilatation, and only the extra-hepatic ducts. These experiments, it should be remembered, were performed on animals, and do not necessarily apply to the human being. We do not remember ever having seen a dilatation of the stump of the cystic duct whilst doing secondary operations on the bile-ducts, though it is not at all uncommon for a varying length of the cystic duct to be left after cholecystectomy. Moreover, American experimenters seem to have satisfied themselves that though at first there is some holding up of the bile in the extra-hepatic ducts, very soon the pressure causes the sphincter of Oddi to yield, and thereafter bile escapes continuously. Indeed, this permanent relaxation of the sphincter is one of the reasons advanced for performing cholecystectomy in cases of chronic pancreatitis, the cause of bile regurgitating into the pancreatic duct being thereby removed.

In Chapter VII, Hartmann deals with the technique of operations on the bile-ducts. During the operations he stands on the left of the patient, as he thinks he is able to get an easier and a better view of the whole operative field. He describes his method of conducting all the usual operations in this region; there is, however, nothing of particular note in this chapter.

In the next chapter Boppe describes some of the rarer operations, including those required to remedy injuries inflicted on the ducts at previous operations. This is followed by a résumé of the published cases under headings of the type of operation employed, giving the name of the surgeon, the journal in which the publication was made, and also the fate of the patient in each case. This is an excellent article on a very difficult subject.

In Chapter IX, Hartmann, Daniel Petit-Dutaillis, and Uhlrich discuss the immediate and late results of cholecystotomy, cholecystectomy, and choledochotomy. This is a very instructive and stimulating chapter. They show, and most surgeons will agree, that the results after cholecystectomy are a great improvement on those after cholecystotomy. They attempt to explain why it is that some patients con-

tinue to suffer after operations from minor discomforts such as flatulence, eructations, sluggish digestion, and heaviness in the hepatic region. In their opinion these symptoms are liable to appear in cases where the gall-bladder contains multiple stones or muddy bile, and are rarely seen where there are few and large stones, or where there is cholecystitis without stones, and particularly rarely in hydrops of the gall-bladder. They find that patients suffering from these minor ailments have urobilin in the urine and also a raised cholesterol content of the blood in 83·3 per cent, whereas patients who completely recover after operation show a rise in only 16·6 per cent. According to their view, and contrary to that of Chauffard, hypercholesterolæmia is not the cause of gall-stones, but the manifestation of an abnormality in the hepatic function. It disappears when the hepatic state returns to normal after the operation; it persists when, in spite of operation, the hepatic function remains altered. It seems to us that this is an interesting and important assertion, and one requiring confirmation.

The last three chapters are by Hartmann, and deal with indications for operation in diseases of the bile-passages, with the lesion described under the name of idiopathic cyst of the common duct, and, lastly, with carcinoma of the ampulla of Vater.

At the end of several of the chapters there is an adequate bibliography appended, and in the text views held by recognized authorities are given and commented upon. But the bulk of the work is compiled from the experience of Hartmann and his associates, and coming from such a source ought to be read by everyone whose daily work brings him constantly in contact with affections of the biliary tract.

The Pathological Physiology of Surgical Diseases: a Basis for Diagnosis and Treatment of Surgical Affections. By Professor Dr. Franz Rost, of the University of Heidelberg. Translated by S. P. Reimann, M.D., of the University of Pennsylvania: with a foreword by John B. Deaver, M.D. 8vo. Pp. 535 + xiv. 1923. Philadelphia: P. Blakiston's Son & Co. London: Stanley Phillips. 30s. net.

This is rather an unusual surgical book, and any review must be of a tentative character until its usefulness has been tested. The idea of the work seems to be the application of physiology to the study of disease. The author says in his preface, "it is only by a broadening of physiological conceptions that progress in surgery may be expected". That point may be conceded at once: surgery is not a question of technique, however well mastered. Surgery is a part of medicine, and, as such, a knowledge of anatomy, physiology, and pathology is essential, and it looks as if biophysics must soon be added to the list.

The aim of the book is to give information to the student and young surgeon concerning the vital and more recent physiological discoveries which may affect diagnosis and treatment of diseased organs. A most copious bibliography is appended to each chapter; thus, there are 260 references at the end of the chapter on the stomach, and 306 references to the intestines. The first effect is rather bewildering, and though one grants at once that an application of physiology to surgery is wise and sound, one wishes that the size of the book could have been diminished.

Hernia and its Radical Cure. By J. Hutchinson, F.R.C.S., Consulting Surgeon, London Hospital; Examiner in Surgery, Glasgow University; Formerly Professor at and an Examiner in Surgery to the RC.S., London. Demy 8vo. Pp. 264 + xiii, illustrated. 1923. London: Oxford Medical Publications. 12s. 6d.

"The radical cure of hernia is one of the most successful of all operations, one of the most frequently performed, and one of the greatest importance to the community". All surgeons can agree with this statement by the author in his preface. It is good also that a surgeon of such experience and reputation as Mr. Hutchinson should

emphasize the fact that the operation is not a minor one, and that its real success depends on painstaking technique rather than on rapid performance. It is well, too, that all surgeons, however familiar with the operation, should take stock of their methods from time to time, and see whether they can be improved. This book may be recommended, therefore, to all surgeons, young or old, for in it they will find a well-balanced review of all the ordinary methods of operation now in use.

Naturally there are a few points on which there may be differences of opinion; two of them may be mentioned here. The author has a predilection for kangaroo-tendon as the best material to be used for the buried sutures. There is no doubt that kangaroo-tendon makes a good suture, but there is abundant proof that equally good results may be obtained with catgut, silk, or thread. Thousands of operations for hernia must be performed yearly throughout the civilized world, and one fears there would not be a sufficient number of kangaroo tails to go round if this form of suture were obligatory. The other difference of opinion concerns the best form of radical cure for a femoral hernia. Mr. Hutchinson prefers the older method of approaching the hernia from Scarpa's triangle, whereas the inguinal route appears now to find greater favour among the newer generation of surgeons. Both methods, however, are well described, and the point is open to argument.

Mr. Hutchinson is to be congratulated on a masterly exposition of an important subject, and also on the fact that he has expressed himself clearly in a short compass.

A Practical Handbook on Diseases of the Ear. By Sir William Milligan, M.D., Aurist and Laryngologist to the Royal Infirmary, Manchester; Consulting Surgeon to the Manchester Ear Hospital; and Wyatt Wingrave, Pathologist (lately Physician) to the Central Throat and Ear Hospital, London. Demy 8vo. Pp. 191, illustrated. 1923. London: William Heinemann Ltd. 12s. 6d. net.

It may be said at once that in their attempt to present the senior student of medicine with "a concise account of the more ordinary diseases of the ear met with in general practice" the authors have eminently succeeded in their task. Futhermore, we feel sure that experienced otologists and pathologists will not read this excellent handbook without considerable profit to themselves. From cover to cover it provides the reader with a splendid résumé of our present knowledge of diseases of the ear and their pathology. These are presented to the student in a clear, precise, scientific, and withal easy style, and are illustrated by a series of, for the most part, excellent diagrams, drawings, and photographs.

Chapter I deals with the physiology of the ear, and is excellent. Chapter II is devoted to the examination of the ear, nose, nasopharynx, and pharynx. We are glad to note the authors' condemnation of most of the aural syringes on the market, which are useless or harmful because of their thick conical nozzles. It is difficult to conceive of a better description of the various tests employed in cases of deafness; but why do the authors speak of the Galton-Edelmann 'pfeiffe' in one paragraph (page 22) and supply its English translation—whistle—in the next?

We would suggest that "inflation of the ear through the Eustachian catheter" (page 33) might be less painful to the patient in inexperienced hands if the Politzer's bag (*Fig.* 18) were fixed to the catheter rather than to the rubber bottle illustrated in *Fig.* 23.

Chapters V and VI on diseases of the auricle and external meatus give the best description of their pathology, symptoms, and treatment with which we are acquainted. The illustrations are excellent, and here, as throughout the volume, the authors never fail to impress the reader with the need for paying due regard to the general health of the patient, e.g., chronic dry catarrh of the middle ear (page 116).

In Chapter X, "Exudation or Moist Catarrh of the Middle Ear", we should like to see emphasis laid on this condition as an almost constant sign of malignant disease of the nasopharynx. Again, the fine moist crepitations heard by the examiner

with the auscultation tube are a better diagnostic sign of the exudative catarrh than the 'dark line' on the membrane, which is frequently invisible.

Chapter XIV contains an excellent account of tuberculous disease of the middle ear—a subject which, considering its importance, has been too scantily discussed in most otological text-books.

Chapters XV and XVI give us a very complete and clear account of the suppurative lesions of the middle ear and their complications. The illustrations of operative procedures are just what are needed by the senior student and practitioner. Equally good is Chapter XX, which is devoted to labyrinthine suppuration.

In Chapter XXII will be found many useful formulæ for lotions, 'drops', inhalations, ointments, escharotics, dusting powders, etc. Possibly the greatest value of this chapter lies in the very useful information concerning the methods used in the examination of aural discharges and the various staining media which should be employed. The paragraphs which describe the method of lumbar puncture, and the morbid changes which the cerebrospinal fluid may exhibit under various conditions of disease, are admirable.

We have only one adverse criticism to offer—namely, that the index is not so complete as it should be for such a valuable handbook.

Enlargement of the Prostate. By JOHN B. DEAVER, M.D., LL.D., Sc.D., F.A.C.S., John Rea Professor of Surgery, University of Pennsylvania; Surgeon in Chief to the Lankenau Hospital, Philadelphia; assisted by LEON HERMAN, B.S., M.D., Assistant Surgeon to the Pennsylvania Hospital, Philadelphia. Second edition. Medium 8vo. Pp. 358 + xiii, with 142 illustrations. 1923. Philadelphia: P. Blakiston's Son & Co. $7. London: Bale, Sons, and Danielsson.

THIS is a well-bound, clearly printed monograph. The authors have collected from their practice and from an extensive study of the literature nearly everything that is known, or thought, on this subject. The book is well illustrated; the references at the end of each chapter are most useful; and there is an index.

One naturally turns in a monograph like this to those pages that deal with the author's opinions on certain debatable points. Those who have read the recent work of Tandler and Zuckerkandl on the enlarged prostate will have been impressed by the numerous arguments they advance to prove the origin of enlargements of the prostate from that group of glands called the subcervical urethral. The authors refer to their work, and quote the observations of Lowsley on the embryology of the prostate, but do not accept their views; the reader is left a little puzzled to account for this non-acceptance, as the arguments the authors produce are not at all convincing. In *Fig.* 44 they represent the ejaculatory ducts as running through the substance of the enlarged gland, and not displaced posteriorly; it would be interesting to know whether this is a drawing from a dissection, or merely a diagram representing the authors' views on this subject.

There is a full discussion on the etiology of this condition, and it is interesting to find that the one factor that is common to almost every case is the age of the patient.

Another section which every surgeon will study is that dealing with the comparative value of the various tests of the kidney function. They state that Ambard's constant and cryoscopy have not met with much favour in America. They seem to place most reliance on the phthalein test and estimation of the blood-urea, but state emphatically that they are all very largely guided by the general condition of the patient. In discussing the latter, one is surprised to find no reference to the condition of the tongue.

Although the authors do not expressly state it, certain facts seem to emerge after a study of this section of the book.

1. In spite of the emphasis laid on the value of an estimate of the patient's general condition, this is not to be relied on; otherwise there would be no necessity for the numerous tests of kidney function.

2. In spite of the authors' defence of the phthalein test, this has proved to be absolutely unreliable. They quote case after case from their own experience and from the literature where a patient with an excellent phthalein output has, after prostatectomy, promptly died of uræmia ; also cases where the patient, in spite of a very scanty output (which has continued scanty after a preliminary cystotomy), has been operated on and made an excellent recovery.

3. It seems unreasonable to assume that the combination of two unreliable factors, the general condition of the patient and his reaction to the phthalein test, should produce a certainty in diagnosis, and nothing short of this is of any use to the patient.

4. The blood-urea test seems to some surgeons the most direct and reliable of the tests yet invented ; but time alone will show if it is absolutely good from the point of view of prognosis in these cases of prostatectomy.

There is an excellent chapter on the indications for radical treatment by suprapubic or perineal prostatectomy, and the authors' remarks on the advisability in some cases of a two-stage operation, and on the arrest of bleeding after operation, are worth reading. Few modern urologists will agree with the authors' view that there are cases in which the clipping off of a projecting middle lobe is all that is necessary.

Encyclopædia Française d'Urologie. Edited by Dr. A. Pousson, Professeur à la Faculté de Médecine de Bordeaux, and Dr. E. Desnos, Sécrétaire Général de la Société Internationale d'Urologie. Vol. V, pp. 1110, and VI, pp. 1086. 1922. Paris : Octave Doin. Vol. V and VI, each 60 fr. ; Vols. I to VI, complete, 300 fr.

These two compendious volumes, comprising in all 2196 pages, form parts of an important work on urology by various French authors. The scheme of the work is encyclopædic. The literature of each subject is collated, and a very extensive classified bibliography is given at the end of each chapter. The views and methods of many authorities are concisely given, without interfering unduly with the thread of the narrative.

Volume V has 1110 pages which are entirely devoted to diseases of the urethra. Among many important articles may be noted examination of the urethra and urethroscopy by Noguès and Papin, some excellent coloured illustrations being included. Stricture of the urethra and its complications is described in 215 pages by Escat, and further space is devoted to the technique of operations on the urethra by Noguès, Heitz Boyer, and Genouville.

Volume VI deals in 1086 pages with diseases of the prostate and urinary symptoms in general. There are chapters on the examination and injuries of the prostate (André), inflammation, calculi, and cysts (Craison), hypertrophy (Marion), malignant tumours (Pauchet), tuberculosis (Erzbishoff), etc.

The extent and thoroughness of the work may be gauged by the fact that the article on hypertrophy of the prostate by Marion extends to 187 closely printed pages, with an additional 16 pages for the bibliography. In this section the author gives an account of the present knowledge of simple enlargement of the prostate and its treatment. In another section he describes the operative technique he personally adopts. The section on urinary symptoms includes such mechanical conditions as retention and incontinence of urine (Delbet), and abnormal conditions of the urinary secretion and composition, such as anuria, phosphaturia, oxaluria, glycosuria, etc.

It is impossible to discuss the various subjects in detail, but it may be said that the thoroughness with which the literature is collated, and the high standard of the discussion, are maintained throughout. These volumes form, with the others which have already appeared, one of the most extensive and authoritative publications on urology at the present time. They should form a part of the reference library of every urinary surgeon, and may be recommended to the notice of physicians studying the medical aspects of urinary disease.

Cancers du Rein, de la Glande Surrénale, et des Voies Urinaires Supérieures. By P. LÉCÈNE, Professeur à la Faculté de Médecine de Paris, and G. WOLFROMM, Préparateur à la Faculté de Médecine de Paris. Roy. 8vo. Pp. 212, with 32 illustrations. 1923. Paris: Gaston Doin. 15 fr.

THIS is one of a series of monographs on cancer—*Bibliothèque du Cancer*—published under the direction of Professors Hartmann and Bernard, of which cancer of the intestine has already been issued, and two others are in the press: thyroid cancer, and cancer of the rectum.

This monograph gives an excellent account of the tumours of the kidney, adrenal, and ureter; it is well illustrated, and some of the microscopical sections are admirably reproduced. We do not think it contains much new material, but it may be consulted as an epitome of what is known on this subject.

Perhaps the most striking point in this book is the following quotation from the preface to the second edition: "It is an impressive fact that the operation which we advised in the previous edition should be performed only after all palliative means have been tried without success, is now justifiable as a primary procedure, and one far safer in the average case than any form of palliation." With this statement surgeons on this side of the Atlantic heartily agree, provided that the patient is not already the subject of a painless retention nor the victim of injudicious catheterization.

Particularly interesting and full descriptions are given of tumours of the pelvis of the kidney and of paranephric new growths.

Chirurgie Vasculaire Conservatrice. By P. MOURE, Chirurgien des Hôpitaux de Paris. Crown 8vo. Pp. 144 + x, with 110 illustrations. 1923. Paris: Masson et Cie. 12 fr.

THIS book belongs to a series of medical monographs appearing from time to time according to the needs of the moment. The object of the work is to show that suture and grafting of blood-vessels should be removed from the domain of experimental surgery and taken into everyday use. The first part is descriptive of the technique of blood-vessel suture, and the second of the indications and applications to human surgery. The work is well done, clearly illustrated by diagrams, and should prove of practical use to any one interested in this line of surgery.

Medical Practice in Africa and the East. Edited by HUGH MARTIN, M.A., and H. H. WEIR, M.A., M.B., with an introduction by STEPHEN PAGET, F.R.C.S. Crown 8vo. Pp. 111 + xi. 1923. London: Student Christian Movement. 4s. net. Paper covers, 2s. 6d. net.

THIS is an interesting and well written account of 'pioneer' practice in the outlying districts of the world where modern science is still unknown. The scope is shown by the sub-title, which runs, "a series of open letters on professional subjects from doctors practising abroad, addressed to their colleagues at home". The letters prove how much can be done by earnest-minded men, well skilled in the medical profession, who are willing to sacrifice their own comfort for the good of their fellow-creatures and to lay up for themselves treasure "where neither rust nor moth doth corrupt." By those young men and women who have such an ideal the book will be bought and eagerly read.

SHORT NOTES ON BOOKS.

Surgical 'Don't's' and 'Do's'. By C. HAMILTON WHITEFORD, M.R.C.S., L.R.C.P., Hon. Surgeon to the Plymouth Infirmary. Crown 8vo. Pp. 46. London: Harrison and Sons Ltd. 3s.

A SMALL book full of practical wisdom, some of which is wisely said.

Topographische Anatomie dringlicher Operationen. By J. TANDLER, Professor of Anatomy, Vienna. Second edition. Pp. 118, with 56 figures. Berlin: Julius Springer. 8s. 4d.

THIS small book is intended to present the anatomical picture of those regions in which operations of emergency may have to be performed. It is concerned with ligature of arteries, and with abdominal, chest, and urinogenital surgery. The great feature which recommends it is the very beautiful half-tone and coloured illustrations. These are so good that we would wish for a larger work on the same lines dealing with the surgical anatomy of the whole body.

Grundriss der gesamten Chirurgie, ein Taschenbuch für Studierende und Arzte. By Professor ERICH SONNTAG, Leipsic. Second edition. Pp. 937. Berlin: Julius Springer.

THIS is a very closely-printed and much-condensed synopsis of surgery. It includes an account of general surgery, special surgery, and a summary of operative surgery. It represents a very great amount of information compressed into a small space, and is certainly of value for purposes of reference.

Surgical Nursing and After-treatment: a Handbook for Nurses and others. By H. C. RUTHERFORD DARLING, M.S., F.R.C.S., Surgeon, Coast Hospital, Sydney. Second Edition. Pp. 566, with 138 illustrations. London: J. & A. Churchill. 8s. 6d.

THIS book is written in accordance with the syllabus of the Australian Trained Nurses' Association. It is a treatise on elementary surgery as well as a careful text-book of surgical nursing. The style and printing are clear, and the illustrations are simple and well chosen. It concludes with a useful appendix, giving weights and measures, diets, etc.